GE 136C: Spring 2026 Field Guide

Sierra Nevada, Kings Canyon, Kern River & Carrizo Plain

The Kern River winding through its canyon near Kernville, on the western slope of the southern Sierra Nevada. Fed by snowmelt from Mount Whitney and the high country of Sequoia National Park, the Wild & Scenic Kern drops steeply through granite of the southern Sierra batholith before reaching Lake Isabella and the southern San Joaquin Valley. Each spring the range exhales its winter snowpack, and that meltwater becomes the lifeblood of California — slaking the thirst of tens of millions, braiding into wetlands and riparian corridors that shelter countless species, and carving the valleys and laying down the soils that have drawn people to this landscape for millennia. The mountains keep no calendar and ask for nothing in return; they simply gather snow, release water, and shape the living world downstream.

Instructor: Joe Kirschvink
TAs: Nick Anderson, Sophia Westerkamp
Cover Photo: Courtesy of a Kern River rafting outfitter

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Note: All times are approximate. Forest Service road conditions to Mono Creek Campground and Ikigai Sanctuary must be verified before departure. Check the Sierra National Forest alerts page (fs.usda.gov/sierra) and Sequoia National Forest alerts (fs.usda.gov/sequoia). Kern River flow and rafting conditions: dreamflows.com/flows.php. Weather at higher elevations (Mono Creek ∼7,400 ft) can drop below freezing overnight even in late May — pack accordingly.

1 Schedule

1.1 Field Trip Schedule — May 29 – June 1, 2026

Day	Time	Stop	Coordinates	Talks
Day 1 — Friday, May 29, 2026				
Day 1	8:00 AM	Depart Pasadena (Arms Circle, Caltech)	34.1362, −118.1268	—
Day 1	~11:30 AM	**Colonel Allensworth State Historic Park** — lunch	4011 Grant Dr, Earlimart, CA	Anderson: Colonel Allen Allensworth — From Slavery to Founding a Town; Keebler: Tejon Oil Country — Geologic & Human History; Alcabes: Boswells, Resnicks & Singletons — California's Billionaire Farmers
Day 1	~2:10 PM	**San Joaquin Hatchery**	17372 Brooktrout, Friant, CA	Sharples: What Happens at a Fish Hatchery?
Day 1	~2:50 PM	**Vernal Pools & Mortar Bowls**	36.9719, −119.7167	Davis: Vernal Pools — A Disappearing Ecosystem; Moorman: Atmospheric Rivers & Flooding in California
Day 1	~4:05 PM	**Museum of the Sierra**	42642 Tollhouse Rd, Shaver Lake, CA	Langley: Big Creek Hydroelectric Project
Day 1	~6:20 PM	**Mono Creek Campground** — Night 1 (sites 001, 003, 004, 005, 006)	37.3547, −118.9969	Bednarick: Granite Crystallization, Types (S/I/A) & Protoliths; Ree: Magmatic History of the Sierra Nevada Batholith; Zhang: Geochemistry of Mono / Remington / Miracle Hot Springs; Mukherjee: John Muir & the Preservation of the Sierra Nevada; Lin: The John Muir Trail; Horak: Yosemite Toad & Skin Bacteria
Day 1	~8:30 PM	**Mono Hot Springs** (short drive from camp)	37.3264, −119.0177	— (informal soak; talks continue on return)
Day 2 — Saturday, May 30, 2026				
Day 2	7:00 AM	Breakfast; pack up Mono Creek camp	—	Kwiecinski: Fire Ecology of the Western Sierra & Effects of Suppression / Climate Change (delivered in the burn scar)
Day 2	~9:00 AM	Depart Mono Creek for Fresno	—	—
Day 2	~12:10 PM	**Simonian Farms** — lunch	2629 S Clovis Ave, Fresno, CA	von Emster: History & Science of Sierra Nevada Snow Surveys; Nazareth: Milankovitch Cycles & Sierra Glaciation
Day 2	~3:00 PM	**Boyden Cavern** (Group 1, 25 + 7 slots needed)	36.8151, −118.8194	Yoshioka: Boyden Cave & the Kings Canyon Roof Pendant
Day 2	~4:00 PM	**Boyden Cavern** (Group 2)	36.8151, −118.8194	Stenmark: Glacial Geomorphology — Arêtes, Cirques, Glacial Lakes & Moraines

(continued on next page)

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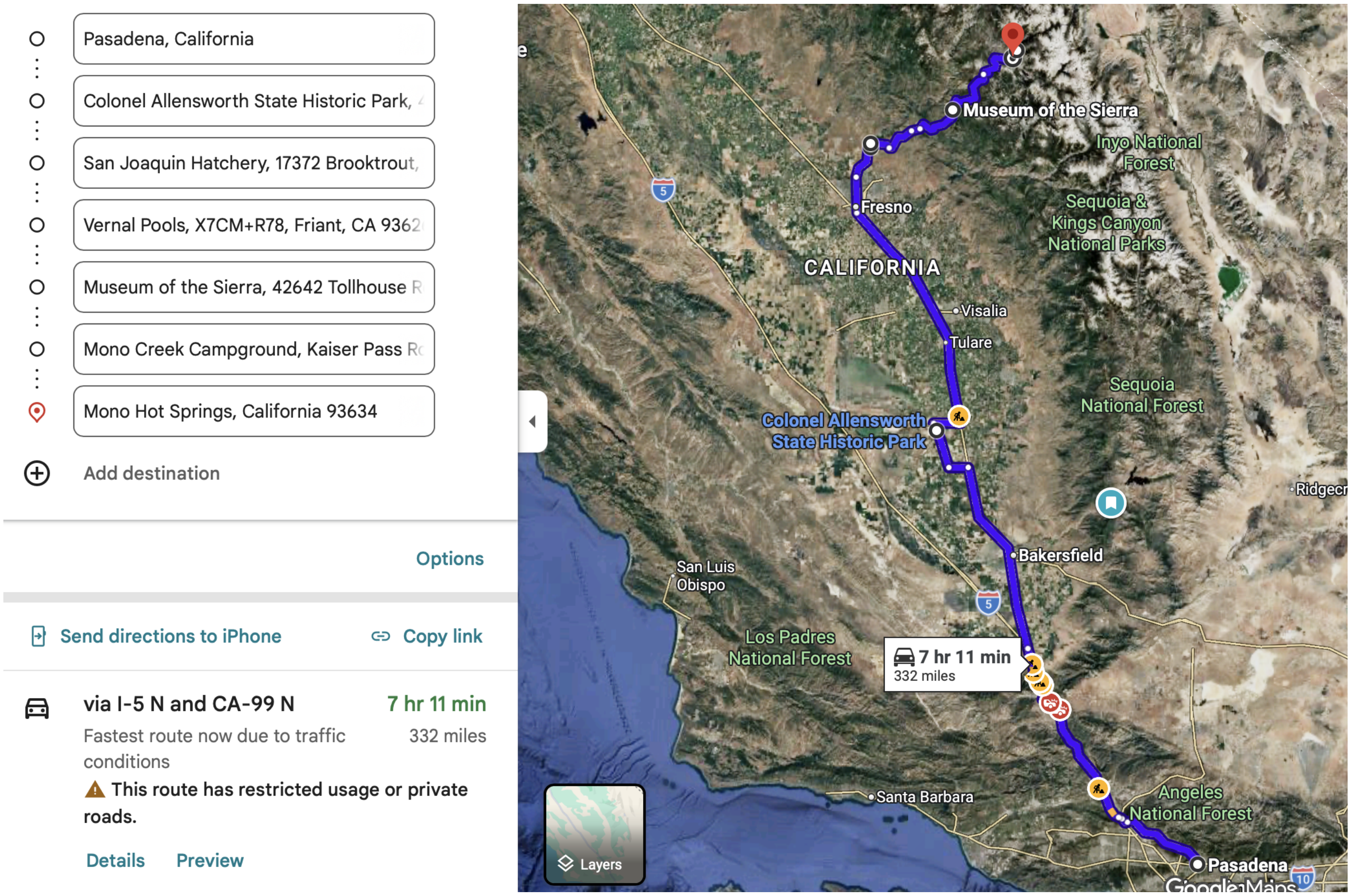
Day	**Time**	**Stop**	**Coordinates**	**Talks**
Day 2	~3:00–6:00 PM	**Kings Canyon "Nonsense"** (concurrent with cavern groups)	[TODO coords]	Mirza: Granite Exhumation & Weathering Styles (Exfoliation, Spheroidal, Freeze/Thaw); Thyer: Geochronology & Incremental Assembly of Plutons
Day 2	~7:15 PM	**Ikigai Sanctuary** — Night 2	40580 Ruth Hill Rd, Yokuts Valley, CA	Tongco: Antibiotic Resistance in Cattle, Salmon & the California Food Supply; Barbano: Friant Dam, Ancient Lake Tulare & Impacts on Pre-Contact Native California
Day 3 — Sunday, May 31, 2026				
Day 3	7:00 AM	Breakfast; pack up Ikigai camp	—	—
Day 3	~11:50 AM	**Kern River's Edge Campground** — arrive, lunch, change for river	15775 Sierra Way, Kernville, CA	Hannahs: Field Guide to Plants of the High & Low Sierra
Day 3	~1:00 PM	**Sierra South Rafting** (30 booked, need 2 more)	11300 Kernville Rd, Kernville, CA	— (1.5 hr float; class II max)
Day 3	~3:05 PM	**South Creek Falls / Seven Teacups / hike / beach**	[TODO coords]	Glaser: Diminishing Sierra Snowpack & Downstream Effects on Reservoirs / Drinking Water
Day 3	~4:35 PM	**Isabella Dam**	Isabella Main Dam, Lake Isabella, CA	Heiny: Geothermal Energy in California — Casa Diablo IV
Day 3	~5:25 PM	**Kern River's Edge Campground** — dinner	15775 Sierra Way, Kernville, CA	Drake Hernandez: Creation Stories in Yokut & Tübatulabal Cultures; Khristoforova: Hospital Rock — Tübatulabal, Yokuts & Potwisha
Day 3	~7:57 PM	**Remington Hot Springs** (short drive from camp)	[TODO coords]	— (informal soak)
Day 4 — Monday, June 1, 2026				
Day 4	7:30 AM	Breakfast; break Kern River's Edge camp	—	—
Day 4	~9:30 AM	**BookHounds** (used bookstore, Bakersfield)	2710 L St, Bakersfield, CA	—
Day 4	~12:00 PM	**Soda Lake** (Carrizo Plain)	35.2196, −119.8980	Edwards: Thenardite Mineralogy & Soda Lake
Day 4	~12:40 PM	**Painted Rock** (Carrizo Plain) — lunch	35.1454, −119.8619	Thalhammer: Carrizo Plain, Global Desertification & Valley Fever (Soil Fungus)
Day 4	~2:30 PM	**Pine Mountain General Store** — fuel & restrooms	2513 Freeman Dr, Frazier Park, CA	—
Day 4	~4:00 PM	**MWD Foothill Power Plant**	32130 Lake Hughes Rd, Castaic, CA	—
Day 4	~4:40 PM	**Castaic Lake Swim Beach**	G94P+FG, Castaic, CA	—
Day 4	~5:30 PM	**Los Angeles Aqueduct Cascades** (Sylmar)	Foothill Blvd, Sylmar, CA	Bingo & word search for the drive home (see §7)
Day 4	~6:30 PM	Arrive Caltech / Pasadena (Arms Circle)	34.1362, −118.1268	—

2 Routes

2.1 Day 1: Friday May 29, 2026 — Pasadena to Mono Creek

Route Summary: Pasadena → I-5 N → CA-43 / CA-99 N (Earlimart for Allensworth) → CA-99 N to Fresno → CA-168 E (Friant / Shaver Lake) → Kaiser Pass Rd → Mono Creek Campground. Mono Hot Springs is ~2 miles further down Kaiser Pass Rd.



○ Pasadena, California
○ Colonel Allensworth State Historic Park,
○ San Joaquin Hatchery, 17372 Brooktrout,
○ Vernal Pools, X7CM+R78, Friant, CA 9362
○ Museum of the Sierra, 42642 Tollhouse R
○ Mono Creek Campground, Kaiser Pass R
Mono Hot Springs, California 93634

⊕ Add destination

Options

Send directions to iPhone   Copy link

via I-5 N and CA-99 N   7 hr 11 min

Fastest route now due to traffic conditions   332 miles

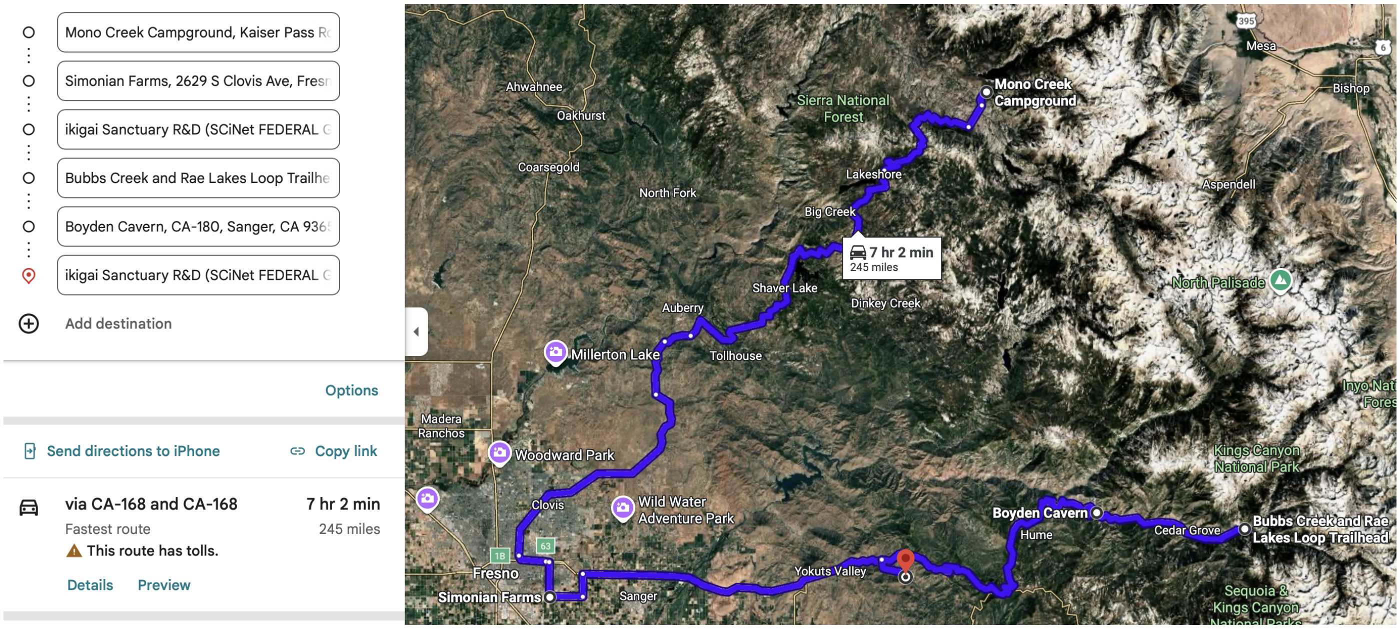
⚠ This route has restricted usage or private roads.

Details   Preview

Museum of the Sierra
Inyo National Forest
Sequoia & Kings Canyon National Parks
5
Fresno
CALIFORNIA
Visalia
Tulare
Sequoia National Forest
Colonel Allensworth State Historic Park
Ridgecr
Bakersfield
San Luis Obispo
5
Los Padres National Forest
7 hr 11 min
332 miles
Santa Barbara
Angeles National Forest
Pasadena
10
Layers
Google Maps

2.2 Day 2: Saturday May 30, 2026 — Mono Creek to Ikigai Sanctuary

Route Summary: Mono Creek Campground → Kaiser Pass Rd back to CA-168 W → Fresno (Simonian Farms lunch) → CA-180 E into Kings Canyon NP → Boyden Cavern → Kings Canyon scenic stops (Cedar Grove / Roads End area) → back out CA-180 W → Ikigai Sanctuary near Yokuts Valley.



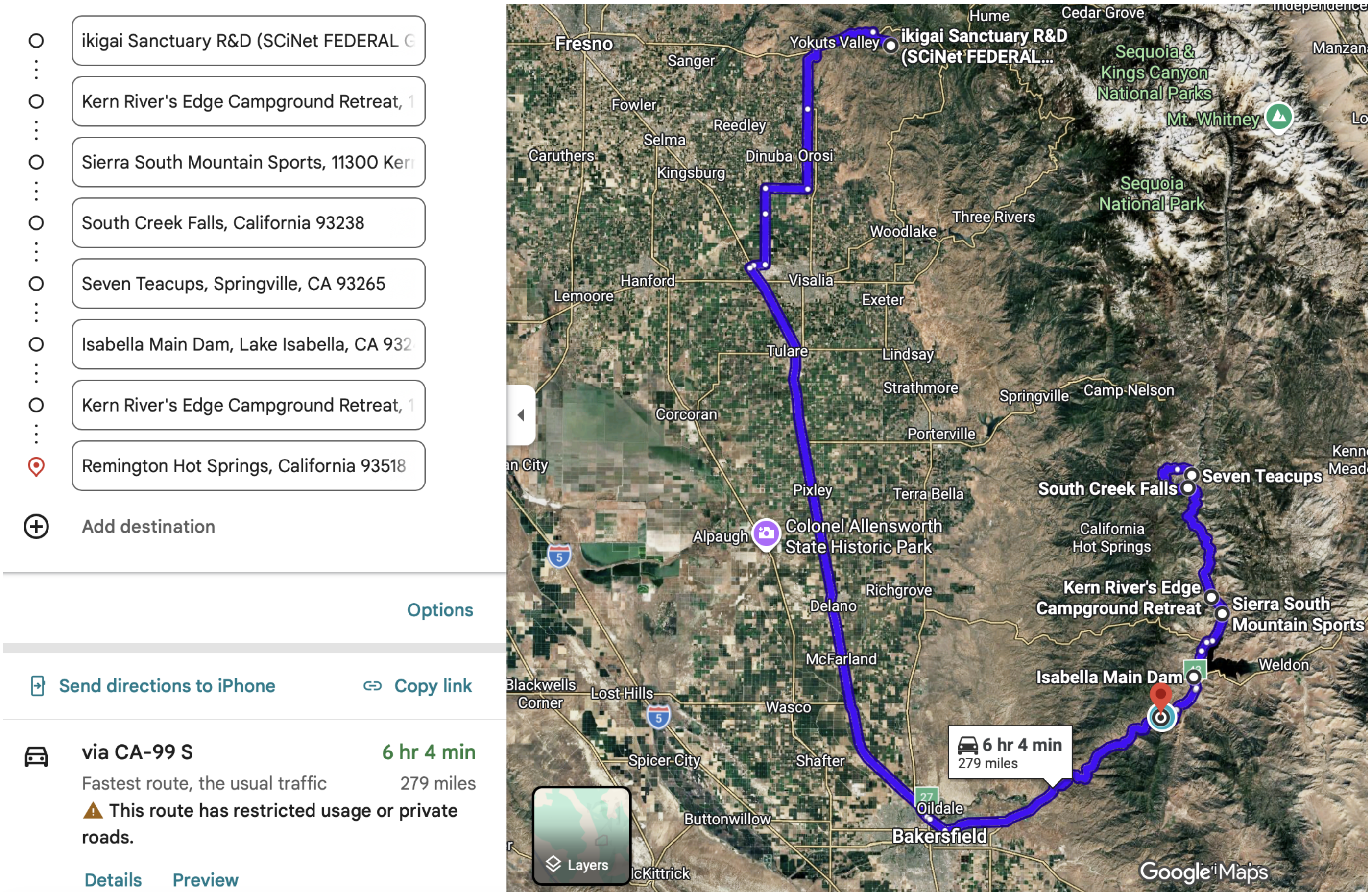
- ○ Mono Creek Campground, Kaiser Pass R
- ○ Simonian Farms, 2629 S Clovis Ave, Fresn
- ○ ikigai Sanctuary R&D (SCiNet FEDERAL
- ○ Bubbs Creek and Rae Lakes Loop Trailhe
- ○ Boyden Cavern, CA-180, Sanger, CA 936
- ikigai Sanctuary R&D (SCiNet FEDERAL

via CA-168 and CA-168 — 7 hr 2 min
Fastest route — 245 miles
⚠ This route has tolls.

Add destination
Options
Send directions to iPhone
Copy link
Details
Preview
7 hr 2 min
245 miles
Mono Creek Campground
Sierra National Forest
Ahwahnee
Oakhurst
Coarsegold
North Fork
Lakeshore
Big Creek
Shaver Lake
Dinkey Creek
Auberry
Tollhouse
Millerton Lake
Madera Ranchos
Woodward Park
Clovis
Wild Water Adventure Park
Fresno
Simonian Farms
Sanger
Yokuts Valley
Boyden Cavern
Hume
Cedar Grove
Bubbs Creek and Rae Lakes Loop Trailhead
Kings Canyon National Park
Sequoia & Kings Canyon National Parks
North Palisade
Inyo Nati Fores
Aspendell
Bishop
Mesa
395
6
180
63

2.3 Day 3: Sunday May 31, 2026 — Ikigai to Kernville

Route Summary: Ikigai Sanctuary → CA-245 S → CA-65 S → CA-155 E over Greenhorn Mountains → Kernville (Kern River's Edge Campground) → Sierra South Rafting → South Creek Falls / Seven Teacups along Kern River → Isabella Dam → back to camp for dinner → Remington Hot Springs (south of Kernville on SH-99 / Sierra Way).



○ ikigai Sanctuary R&D (SCiNet FEDERAL

○ Kern River's Edge Campground Retreat,

○ Sierra South Mountain Sports, 11300 Ker

○ South Creek Falls, California 93238

○ Seven Teacups, Springville, CA 93265

○ Isabella Main Dam, Lake Isabella, CA 932

○ Kern River's Edge Campground Retreat,

Remington Hot Springs, California 93518

Add destination

Options

Send directions to iPhone

Copy link

via CA-99 S — 6 hr 4 min

Fastest route, the usual traffic — 279 miles

⚠ This route has restricted usage or private roads.

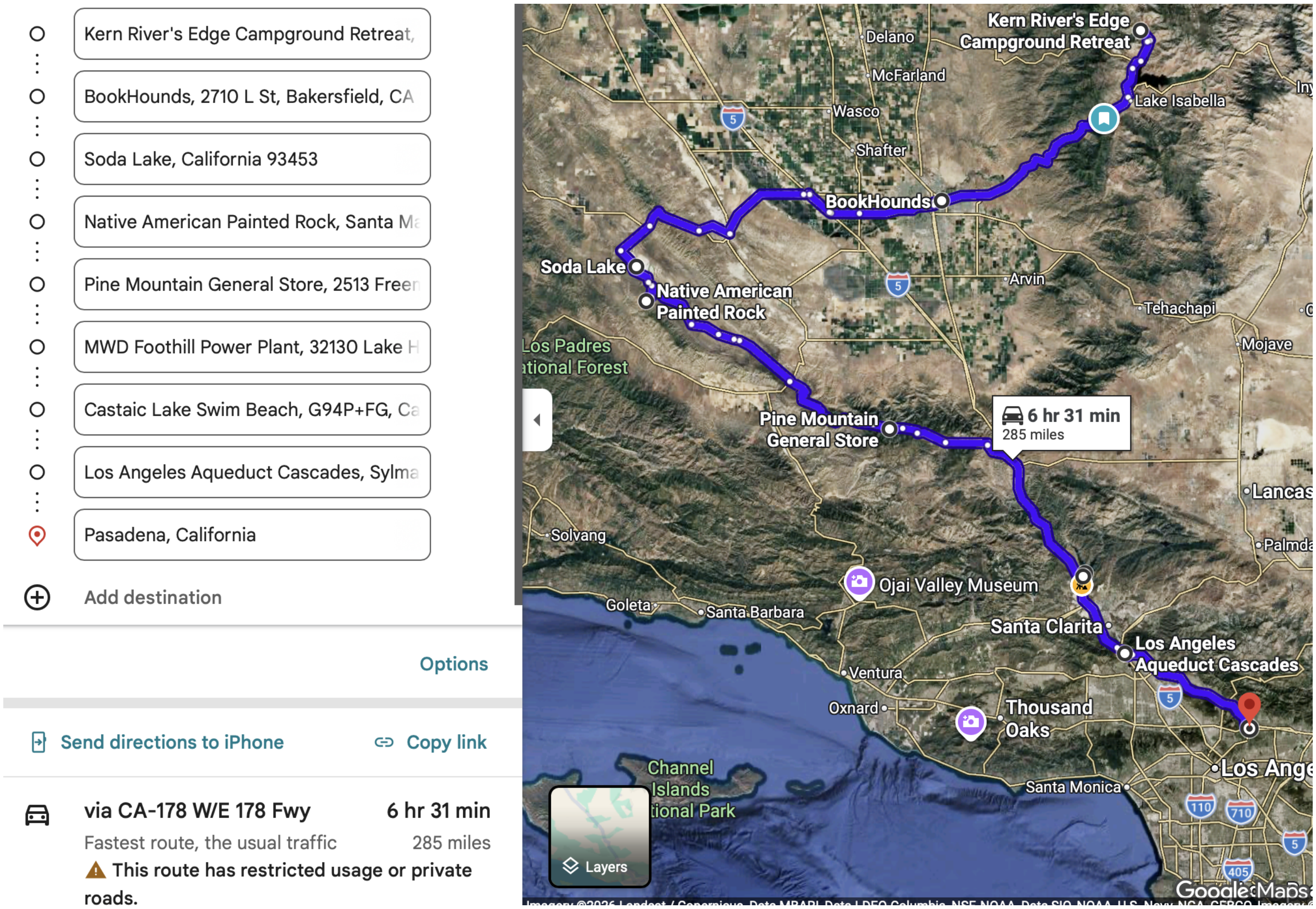
Details

Preview

Fresno
Sanger
Yokuts Valley
ikigai Sanctuary R&D (SCiNet FEDERAL...
Hume
Cedar Grove
Sequoia & Kings Canyon National Parks
Mt. Whitney
Fowler
Reedley
Selma
Caruthers
Kingsburg
Dinuba
Orosi
Sequoia National Park
Three Rivers
Woodlake
Lemoore
Hanford
Visalia
Exeter
Tulare
Lindsay
Strathmore
Springville
Camp Nelson
Corcoran
Porterville
Seven Teacups
South Creek Falls
Pixley
Terra Bella
Alpaugh
Colonel Allensworth State Historic Park
California Hot Springs
Richgrove
Delano
Kern River's Edge Campground Retreat
Sierra South Mountain Sports
McFarland
Weldon
Isabella Main Dam
Blackwells Corner
Lost Hills
Wasco
6 hr 4 min
279 miles
Spicer City
Shafter
Buttonwillow
Oildale
Bakersfield
Layers
Google Maps

2.4 Day 4: Monday June 1, 2026 — Kernville to Pasadena via Carrizo Plain

Route Summary: Kernville → CA-178 W to Bakersfield (**BookHounds** bookstore) → CA-58 W → Soda Lake Rd into Carrizo Plain National Monument (**Soda Lake**, **Painted Rock**) → CA-166 E / I-5 S → **Pine Mountain General Store** (Frazier Park) → I-5 S over the Grapevine → Castaic (**MWD Foothill Power Plant**, **Castaic Lake Swim Beach**) → Sylmar (**Los Angeles Aqueduct Cascades**) → I-210 to Pasadena. *(~285 mi, ~6.5 hr driving.)*



○ Kern River's Edge Campground Retreat,

○ BookHounds, 2710 L St, Bakersfield, CA

○ Soda Lake, California 93453

○ Native American Painted Rock, Santa Ma

○ Pine Mountain General Store, 2513 Freem

○ MWD Foothill Power Plant, 32130 Lake H

○ Castaic Lake Swim Beach, G94P+FG, Ca

○ Los Angeles Aqueduct Cascades, Sylma

Pasadena, California

⊕ Add destination

Options

Send directions to iPhone

Copy link

via CA-178 W/E 178 Fwy — 6 hr 31 min

Fastest route, the usual traffic — 285 miles

⚠ This route has restricted usage or private roads.

Kern River's Edge Campground Retreat
Delano
McFarland
Lake Isabella
Wasco
Shafter
BookHounds
Soda Lake
Arvin
Native American Painted Rock
Tehachapi
Los Padres National Forest
Mojave
6 hr 31 min
285 miles
Pine Mountain General Store
Lancas
Solvang
Palmda
Ojai Valley Museum
Goleta
Santa Barbara
Santa Clarita
Los Angeles Aqueduct Cascades
Ventura
Oxnard
Thousand Oaks
Los Ange
Channel Islands National Park
Santa Monica
Layers
5
110
710
405
Google Maps

3 Useful Information

3.1 Emergency Contacts

- **Trip Leaders:** Nick Anderson (415) 500-5307 [T-Mobile]; Joe Kirschvink (213) 248-3422 [Verizon]; Sophia Westerkamp (719) 648-5461 [Verizon]
- **Caltech Safety Office:** (626) 395-5000
- **Caltech GPS Division:** Claire Bucholz (626) 395-1315; Julie Lee (626) 395-6125
- **GPS Division Satellite Phones:** 881651455634 (primary, carried); 881622445739 (backup)
- **Clovis Community Medical Center** (Western Sierra ER): 2755 E Herndon Ave, Clovis, CA 93611 — (559) 324-4000
- **Kern Valley Healthcare District ER** (Kernville area): 6412 Laurel Ave, Mountain Mesa, CA 93240 — (760) 379-2681
- **High Sierra Ranger Station** (Mono Creek area): (559) 893-2308
- **Ikigai Sanctuary:** +1 (844) 245-4424 / +1 (559) 461-9887
- **Kern River's Edge Campground:** (760) 376-6553
- **Sierra South Rafting** (Kernville): [TODO]
- **Sierra National Forest road conditions:** fs.usda.gov/sierra
- **Sequoia / Kings Canyon NPS conditions:** nps.gov/seki/planyourvisit/conditions.htm

Cell Coverage: Verizon and T-Mobile have decent coverage along I-5, CA-99, and CA-178 corridors and in Kernville. Coverage is **spotty to none** at Mono Creek Campground, Mono Hot Springs, along Kaiser Pass Rd, deep in Kings Canyon, and across most of the Carrizo Plain. The GPS Division satellite phone will be carried at all times.

Trip Roster ($n = 32$): roster. Current roster (alphabetical by last name): Alcabes, Anderson (TA), Barbano, Bednarick, Davis, Drake Hernandez, Edwards, Funaro, Glaser, Hannahs, Heiny, Horak, Keebler, Khristoforova, Kirschvink (instructor), Kwiecinski, Langley, Magyar (staff), Mirza, Mukherjee, Nazareth, Ree, Sharples, Stenmark, Thalhammer, Thyer, Tongco, von Emster, Westerkamp (TA), Wipfler, Yoshioka, Zhang.

3.2 Mono Creek Campground (Night 1)

Location: Sierra National Forest, on the road to Lake Thomas A. Edison just past Kaiser Pass (37.3547°N, 118.9969°W); elevation ∼7,500 ft.

Overview: A small (**only 11 sites total**) USFS campground in a meadow shaded by mature ponderosa pine, ∼15 min drive from Vermilion Valley Resort (limited supplies, pay showers) and a short drive from Mono Hot Springs. Each site has a picnic table, fire ring/grate, and a bear-proof food locker. The area sits within the 2020 Creek Fire burn scar — significant fire-killed timber and ongoing salvage logging remain visible. Reservations open through Recreation.gov; campground is part of the SCE recreational lake/forest network (Edison, Florence, Huntington, Shaver).

Our Booking: We have reserved 5 sites — **sites 001, 003, 004, 005, and 006** — each rated for 6 people, for a total registered capacity of **30**. Our trip roster is 32. **Two participants will need to be "invisible" to the campground host** — distribute them across sites and avoid all five tents being clustered around one fire ring during the host's evening rounds. The host typically does a single headcount at dusk. Keep ID on hand for the reservation holder (Nick).

★ KEY DISCLAIMERS:

- **NO POTABLE WATER AT THE CAMPGROUND.** Water is available at the High Sierra Ranger Station — bring jugs and fill there on the way in, or pack all drinking/cooking water for the night.
- **Hard occupancy cap of 6 per site** — we are 2 over our booked capacity (32 vs. 30 registered). See "Our Booking" above; do not advertise the overage to the host.
- **Kaiser Pass Rd is the limiting factor:** single-lane paved with blind curves, large potholes, drop-offs, and narrow turnouts. Last ∼8 mi takes 45+ min. **No RVs > 25 ft**; rental sedans should be fine in dry conditions but go slow. Plan for a flat tire as a real possibility.
- **Bears are very active here** — food storage in lockers is not optional. Smellables in tents will draw a bear visit.
- **Mosquitos** in late May / early June are notable near the creek and meadow; bring repellent and long sleeves.

Campground Information:

- **Type:** USFS developed campground (Sierra NF, High Sierra Ranger District)
- **Sites:** 11 total at the campground; **we booked sites 001, 003, 004, 005, 006** (6 people/site cap)
- **Reservations:** Recreation.gov (campground ID 232804)
- **Fee:** $37/night per single site, $77/night per double; +$2 holiday surcharge; $6 non-refundable reservation fee
- **Season:** Reservable late May – mid Sept (2025 dates: May 23 – Sept 13). **Verify Kaiser Pass Rd opening before trip.**
- **Restrooms:** Accessible vault toilets
- **Water: None on-site.** Potable water at High Sierra Ranger Station (1.5 mi away)
- **Hookups:** None
- **Cell Service:** None (poor)
- **Trash:** Trash collection provided
- **Quiet Hours:** 10:00 PM – 6:00 AM

Campground Regulations:

- **Fires:** Campfires permitted in established rings with a valid free **California Campfire Permit** (one per group; obtain online at readyforwildfire.org/permits/campfire-permit/). Verify no Sierra NF fire order is in effect at trip time.
- **Firewood: Do not bring firewood from outside the area.** Buy locally to prevent invasive insect spread (firewood.ca.gov). Limited firewood available at Vermilion Valley Resort.
- **Bears:** Store ALL food, trash, toiletries, and scented items in the site's bear locker or a hard-sided vehicle. Never in tents.
- **Pets:** Leashed (≤6 ft)
- **Waste:** Pack out trash if dumpster is full; no dishwashing or liquid waste at water spigots
- **Firearms/Fireworks:** Fireworks always prohibited on USFS land

Access & Navigation:

- **Approach:** From Clovis, CA-168 east 70 mi to Huntington Lake (Eastwood Visitor Center at east end). Right onto Kaiser Pass Rd; 17 mi to Edison Lake Rd. Left onto Edison Lake Rd 4.5 mi to campground.
- **Total drive from Fresno:** ∼3 hours including the slow Kaiser Pass segment
- **Vehicle:** High-clearance recommended (large potholes, washboards). Rental sedans manageable in dry conditions but expect scrapes; carry a spare tire. **No RVs >25 ft.**
- **Snow:** Kaiser Pass typically opens late May/early June — in 2025 the campground was reservable from May 23. **Confirm road open at (559) 855-5355 or with High Sierra Ranger Station (559) 893-2308 the week of the trip.**
- **Gas:** Last reliable gas is in Shaver Lake on CA-168. Vermilion Valley Resort has emergency supplies only. Fill up in Prather/Shaver before Kaiser Pass.
- **Navigation:** Cell-based maps unreliable past Huntington Lake — download offline maps in advance; share paper directions among all drivers

Useful contacts:

- High Sierra Ranger Station (water, info, road status): (559) 893-2308
- Sierra NF main office (Prather): (559) 855-5355
- Vermilion Valley Resort (showers, supplies, ∼15 min drive): edisonlake.com

Nearby:

- Mono Hot Springs (∼2 mi)
- Lake Thomas A. Edison (∼3 mi)
- Vermilion Valley Resort (limited store, pay showers, ∼15 min drive)
- Florence Lake trailhead (∼8 mi)
- Ansel Adams & John Muir Wilderness trailheads

3.3 Camp ikigai Animal Sanctuary (Night 2)

Location: 40580 Ruth Hill Rd, Yokuts Valley (formerly Squaw Valley), CA 93675 (36.7346°N, 119.1267°W); elevation ∼1,500 ft (Sierra foothills, oak woodland).

Overview: A 72-acre off-grid private animal sanctuary (501(c)(3) nonprofit) and ag-tourism campground at the foot of the western Sierra, ∼40 min from Fresno and ∼30 min from the Kings Canyon NP entrance at Big Stump. The property is a former 100-year cattle ranch and gold mine, now home to free-roaming horses, sheep, dogs, and cats. The site is run by founder Matt L. Downer ("GuyOnTheRanch") and offers a mix of tiny cabins, glamping options, and dispersed tent/RV/car sites; the booking platform is ResNexus via campikigai.com. Communal areas include a campfire ring, outdoor kitchen space, and 12 miles of internal roads/trails connecting to 140 adjacent acres of BLM land.

★ KEY DISCLAIMERS:

- **This is an animal sanctuary, not a campground.** Free-roaming animals (horses, sheep, dogs) are present throughout the property. **Do not feed, ride, or chase any animals. Close every gate behind you** — the horses are reputed escape artists.
- **The site is off-grid and primitive.** Restrooms are outhouses; showers are outdoor and shared. Power and water are limited; do not expect hookups, paved sites, or 24/7 lighting.
- **Site is dog-friendly and there is a resident dog (Timber).** Inform anyone with allergies or dog fears in advance.
- **Quiet hours and intentional-community ethos:** Ikigai markets itself as a sanctuary first and an intentional community — avoid loud music, fireworks (always banned), and disruptive behavior. Keep talks/group discussions to designated communal areas after dark.
- **Cell service is spotty.** AT&T tends to work best; Verizon/T-Mobile are intermittent. There is no reliable Wi-Fi.

Site Information:

- **Type:** Private 72-acre off-grid animal sanctuary & campground (501(c)(3))
- **Accommodations available:** Tiny cabins (e.g., "The Yurttle", "Birdhouse"), glamping tents (coming), dispersed tent/RV/car/van/skoolie sites, hike-in hammock sites
- **Our booking:** [TODO — confirm site type(s) booked]
- **Booking platform:** ResNexus via campikigai.com
- **Fee:** [TODO]
- **Restrooms:** Outhouses (shared, outdoor)
- **Showers:** Outdoor shared showers
- **Water:** Potable water on-site (per safety plan); bring jugs as backup
- **Cell Service:** Spotty (AT&T best); no reliable Wi-Fi
- **Cooking:** [TODO — confirm cooking setup with Sophia]

House Rules (per host):

- **Close every gate behind you** — animals roam freely
- Do not feed, ride, mount, or chase the horses, sheep, dogs, or cats; supervise any children with the animals
- No fireworks; campfires only in designated communal fire ring (CA Campfire Permit required if a fire ban is in effect)
- Pack-out trash; respect quiet hours
- Stoner-friendly site per host's stated policy, but no smoking inside cabins
- Confirm full house-rules sheet at check-in

Directions & Access:

- From CA-180 east (Kings Canyon Hwy), turn onto Dunlap Rd / Ruth Hill Rd; site is on Ruth Hill Rd
- Paved access road; no 4WD required
- Internal sanctuary roads are dirt — drive slowly to avoid animals on the road

Nearby Services:

- Valero gas station: 5 min drive
- Clingans Junction Cafe: 5 min drive
- Dollar General, Indian Trading Post gas, Bear Mountain Pizza: 10 min drive
- Gena's Restaurant (host recommends): 15 min drive
- Kings Canyon NP entrance (Big Stump): ∼30 min drive
- Project Survival Cat Haven: 5 min drive

Host contact:

- Phone: (844) 245-4424 / (559) 461-9887; text (559) 332-0322
- Email: booking@campikigai.com
- Founder: Matt L. Downer ("GuyOnTheRanch")
- Address: 40580 Ruth Hill Rd, Yokuts Valley, CA 93675

3.4 Sierra South Rafting — Lower Kern Float (Day 3)

Location: 11300 Kernville Rd, Kernville, CA 93238.

Overview: 1.5 hour single-person tube float on the Lower Kern with maximum class II rapids. Booked as a group reservation through Sierra South. [TODO — confirm float section and length].

What's provided by Sierra South:

- Single-person inflatable tube (one per participant)
- Paddle / oar
- Helmet
- Personal Flotation Device (PFD)
- Safety briefing on arrival
- Shuttle to put-in and from take-out

What participants should bring:

- Swimwear or quick-dry clothing
- Water shoes or sandals with heel straps (**no flip-flops**)
- Sunscreen (reef-safe preferred)
- Sun hat with chin strap
- Sunglasses on a retainer strap
- Small dry bag with phone / wallet / sandwich (lunch can be carried on the float)
- Water bottle (a leashed bottle is easiest)

Safety Notes:

- Float is **optional**; non-floaters can hike or relax at the campground
- River depth in the float section ranges 2–3 ft typically, with locally 2–8 ft pools; we are **not swimming in deep water**
- Swimming is only allowed in sanctioned swim zones along Mono Creek and the Kern; the Upper Kern above Kernville is class III–V and is **off-limits to the group**
- Known hazard areas in the float section will be avoided per Sierra South briefing

Booking status: 30 adults booked; 2 additional slots needed.

3.5 Kern River's Edge Campground (Night 3)

Location: 15775 Sierra Way, Kernville, CA 93238 (35.7832°N, 118.4436°W); ~2 mi north of Kernville on Sierra Way (SH-99); 1 hr east of Bakersfield. Elevation ~2,700 ft.

Overview: A privately-owned full-service campground on the banks of the Lower Kern River, with 45+ spacious sites in a grassy grove of mature shade trees. Mix of dry sites (tent + small RV) and a limited number of power/water hook-up sites. Onsite amenities include hot showers (coin-operated), clean flush restrooms, a small camp store, sand volleyball court, horseshoe pits, frisbee golf, and a private trail to "The Curve" public beach. The campground is the main staging area for Sierra South Rafting (just down the road) and is well positioned for Lake Isabella, the Whiskey Flat trail system, and Remington Hot Springs downstream on the Kern Wild & Scenic stretch.

★ **KEY DISCLAIMERS:**

- **GLASS CONTAINER PROHIBITION:** The Sequoia NF Kern River Ranger District prohibits glass bottles/containers in the **Kern Canyon and Lake Isabella Glass Container Prohibition Areas**. This covers everything along Sierra Way from Riverkern Beach south to Riverside Park, and most of Lake Isabella shoreline. **Bring only cans, plastic, or aluminum** for beverages and food on and off the campground.
- **Kern River Use Permit required for all boating** (year-round, May 1–Apr 30). Free, issued by Sierra South or USFS. Sierra South will handle this for our group rafting — confirm at check-in. Group size on the river capped at 18 at a time.
- **No RV dump facilities on-site.** Trash and waste must be packed out or used at the campground's bathrooms.
- **Hot showers are coin-operated.** Bring quarters or buy at the camp store.
- **Sequoia NF fire restrictions** typically kick in mid-June (2025: June 18 onward); our Jun 1 stay should fall before the order, but a valid California Campfire Permit is required year-round for fires outside of designated recreation sites. Verify status at fs.usda.gov/r05/sequoia/alerts before the trip.
- **Mountain lions and rattlesnakes** are present in the Kern Canyon; brief participants on rattlesnake awareness (closed-toe shoes, ankle protection, eyes on the trail) before any hiking.

Campground Information:

- **Type:** Private campground (concierge service: firewood + ice delivery on request)
- **Sites:** 45+ spacious sites; group sites accommodate 6, 12, 24, or 36 people
- **Reservations:** Booked — (760) 376-6553 / kernriversedge.com
- **Fee:** ~$58/night and up (varies by site type)
- **Office Hours:** Mon–Fri 10 AM–4 PM; Sat 10 AM–6 PM; Sun 9 AM–3 PM
- **Restrooms:** Deluxe flush toilets, well-kept
- **Water:** Potable water spigots throughout park
- **Showers:** Hot, coin-operated
- **Hookups:** Limited number of power + water hook-up sites; most sites are dry
- **Dump Station:** None on-site
- **Cell Service:** AT&T 5G (excellent); Verizon & T-Mobile LTE (some coverage)
- **WiFi:** Available

Campground Regulations:

- **Campfires:** Allowed in provided fire rings (with cook-top lids); CA Campfire Permit required if fire restrictions are in effect
- **Firewood:** Available on-site (concierge delivery) or at camp store; do not bring outside firewood
- **Glass containers:** Prohibited in Kern Canyon area — **no glass bottles**
- **Pets:** Allowed (dog run on-site); leashed; not in restrooms or store
- **Waste:** No on-site RV dump; pack out trash from off-site stops
- **Alcohol:** Allowed (no glass in canyon)
- **Firearms/Fireworks:** Not permitted

Onsite & Walking-Distance Amenities:

- Camp store (firewood, ice, basic supplies)
- Sand volleyball court, horseshoe pits, frisbee golf
- River access via private trail to "The Curve" beach
- Kernville town (groceries, restaurants, gear shops): 2 mi south
- Sierra South Rafting: 11300 Kernville Rd, ~5 min drive
- Kern River Ranger District Office (Kernville): permits, conditions

Directions: From CA-178 (Lake Isabella Blvd) at Lake Isabella, take Sierra Way (SH-99) north ~12 mi past Kernville. Campground is on the river (east) side, signed. From the south via Bakersfield, follow CA-178 east ~45 mi to the SH-99 junction.

Camp Contact:

- Phone: (760) 376-6553
- Website: kernriversedge.com

3.6 Valley Fever Safety (Cal/OSHA)

This Cal/OSHA worker-safety sheet on Valley Fever (coccidioidomycosis) is reproduced for reference — relevant to the dust exposure at the Carrizo Plain and across the dry San Joaquin Valley. Take care in dusty, disturbed soils; the spores that cause Valley Fever are endemic to this region.

2.07 Valley Fever

May 29, 2018

Regulatory References

California Code of Regulations, Title 8, Section 3203, 5141, 5144, and 1509

Purpose

To prevent the inhalation of Coccidioides immitis fungal spores which can lead to Valley Fever.

Scope

This Code of Safe Work Practice (CSWP) applies to work in areas of the state that are endemic for Valley fever. It applies to any activity that disturbs soil, creates dust or in high dust environments.

I. Requirements

A. Responsibilities

1. Supervisors/Leads
    a. Determine if work area is endemic for Valley Fever. Counties endemic in 2016 are Fresno, Kern, Kings, Madera, San Joaquin, San Luis Obispo, and Tulare. Mariposa, Merced and Monterrey Contact the County Health Department or assume the area is endemic.
    b. Review local Air Quality/Air Pollution District rules on dust control.
    c. Determine if the work to be done will create dust.
    d. Ensure Valley Fever is addressed on the Job Hazard Analysis (JHA)

2. Workers
    a. Review the JHA
    b. Comply with this CSWP and JHA
    c. Inform supervisor if dust cannot be controlled.

B. Excavation and soil disturbance

If dust will be created determine appropriate mitigation and document on the JHA. Engineering controls must be used whenever feasible. The combination of control methods must be sufficient to prevent dust in workers breathing zone. Mitigations may include:

1. Engineering controls

  - a. Wet methods sufficient to prevent airborne dust. Apply water before and during excavation operations
  - b. Chemical dust suppressant or soil binder
  - c. Enclosed cabs with HEPA filters (keep windows closed)
  - d. Wetting or covering spoil piles

2. Administrative controls
    - a. Suspend operations during wind conditions causing excessive dust
    - b. Keep workers up wind.
    - c. Keep workers far enough away to prevent dust from reaching their breathing zone.
    - d. Initiate Stop Work Authority (WREM 73) if controls are not effective.
    - e. Review the California Department of Public Health pamphlet:

      Preventing Workplace Valley Fever

3. Personnel Protective Equipment
    - a. Respiratory Protection--
        - i. N95 filtering facepiece
        - ii. Full or half face respirator with particulate filter
        - iii. Powered air purifying respirator (PAPR) with HEPA filter
    - b. If employees are required to use a respirator all requirements of CSWP 2.03-Respiratory Protection Program must be followed.

Note: Employees may voluntarily use an N95 filtering facepiece. In this case the requirements of CSWP 2.03 do not apply but the employees must be provided the information in CSWP Appendix A 2 Respiratory Protection Program Appendix

C. Travel in Endemic Areas

- a. Keep windows close; use air conditioner or heater
- b. Use recirculate if wind or adjacent activity is causing airborne dust

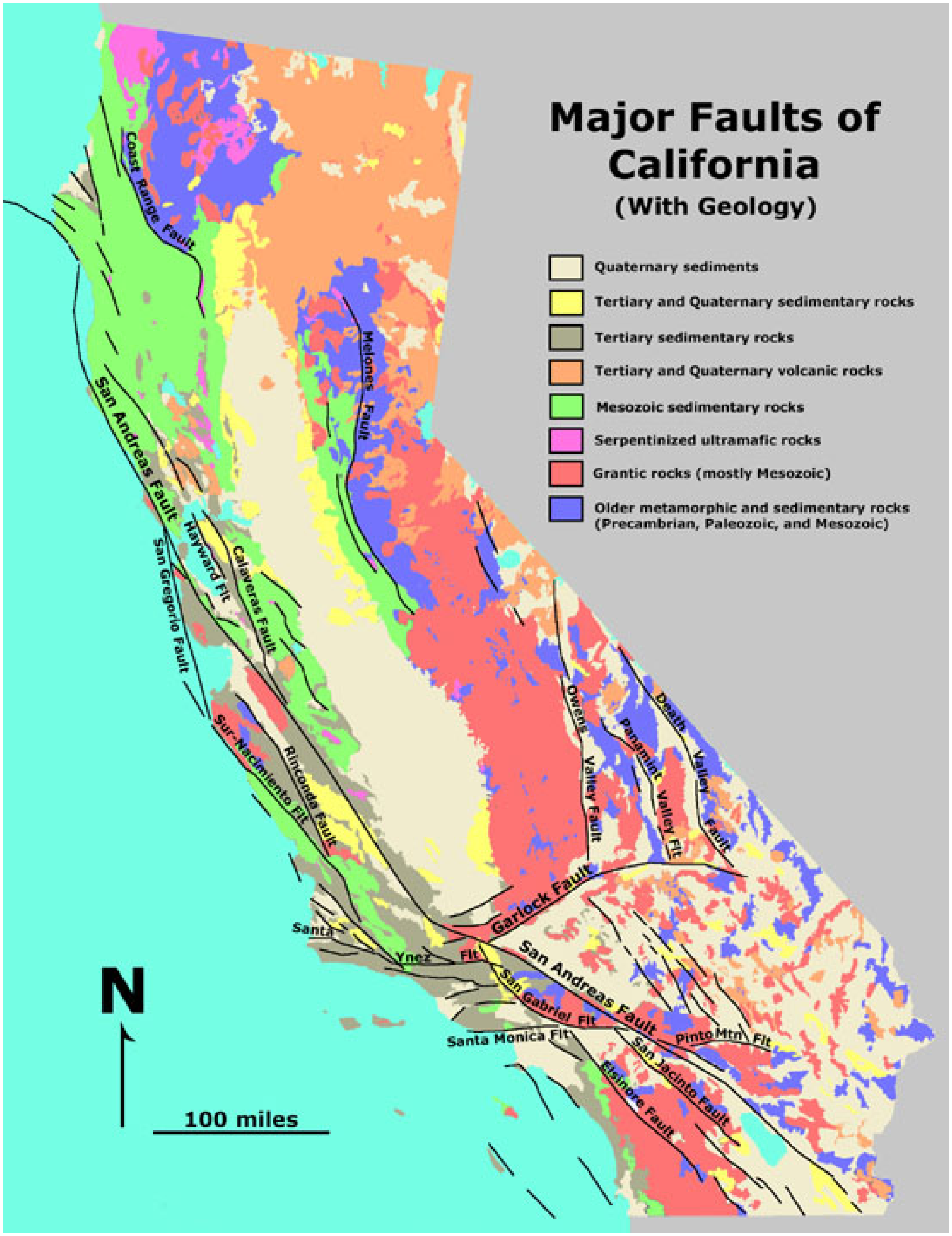
D. Training

1. All employees working in endemic areas shall receive training prior to doing any soil disturbing work.
2. Conduct a tailgate on Valley Fever prior to work if employees have not reviewed training or a tailgate in the previous six months. Information for a tailgate can be found on the California Department of Public Health website:

   Coccidioidomycosis (Valley Fever)

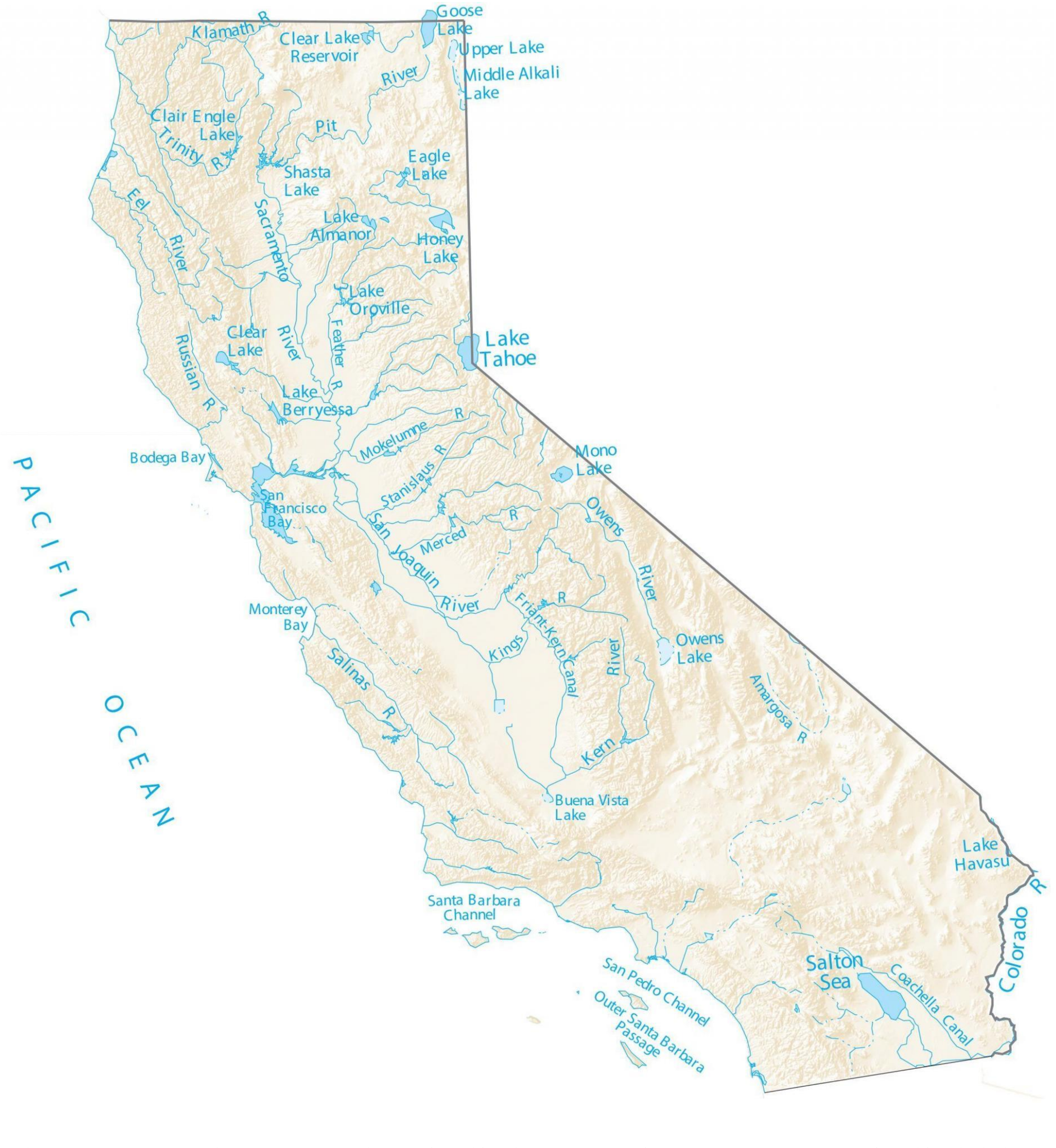
4 Maps

4.1 (1) Major Geologic Units and Faults of California


Major Faults of California
(With Geology)
Quaternary sediments
Tertiary and Quaternary sedimentary rocks
Tertiary sedimentary rocks
Tertiary and Quaternary volcanic rocks
Mesozoic sedimentary rocks
Serpentinized ultramafic rocks
Grantic rocks (mostly Mesozoic)
Older metamorphic and sedimentary rocks (Precambrian, Paleozoic, and Mesozoic)
Coast Range Fault
Melones Fault
San Andreas Fault
Hayward Flt
Calaveras Fault
San Gregorio Fault
Sur-Nacimiento Flt
Rinconda Fault
Owens Valley Fault
Panamint Valley Flt
Death Valley Fault
Garlock Fault
Santa Ynez Flt
San Andreas Fault
San Gabriel Flt
Santa Monica Flt
Pinto Mtn Flt
San Jacinto Fault
Elsinore Fault
N
100 miles

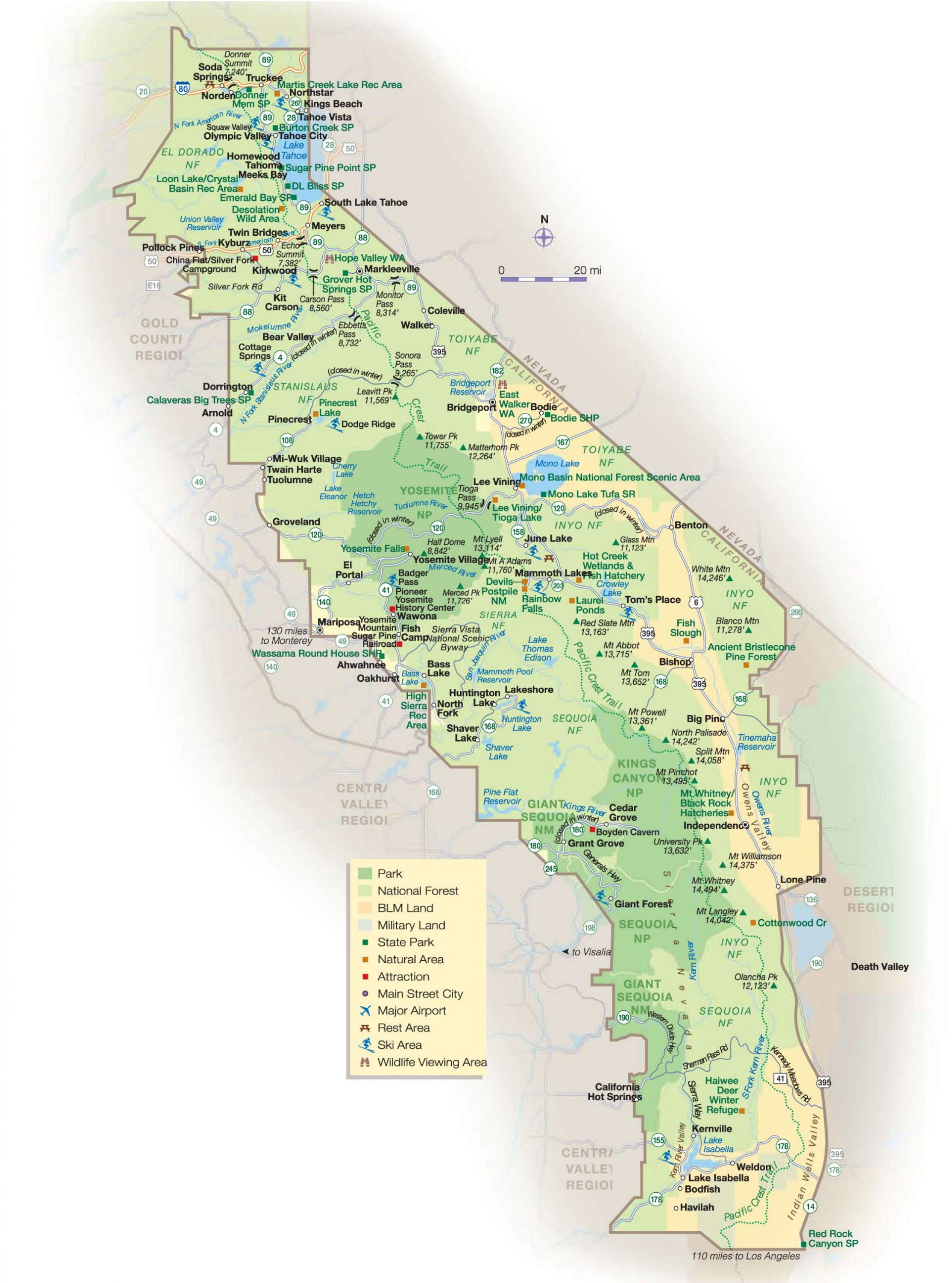
A statewide overview showing California's principal geologic provinces alongside its major fault systems. The state's landscape is governed by the boundary between the Pacific and North American plates — a broad zone of strike-slip faulting dominated by the San Andreas system — which juxtaposes the granitic Sierra Nevada, the sedimentary Great Valley, the Coast Ranges, and the desert provinces. These structures control where mountains rise, where basins subside, and where the seismicity that defines life in the state is concentrated; the trip crosses several of them between the Sierra and the coast.

4.2 (2) Major Streams, Rivers and Lakes of California


Klamath R
Clear Lake Reservoir
Goose Lake
Upper Lake
Middle Alkali Lake
River
Pit
Clair Engle Lake
Trinity R
Shasta Lake
Eagle Lake
Eel River
Sacramento River
Lake Almanor
Honey Lake
Lake Oroville
Feather R
Clear Lake
Russian R
Lake Tahoe
Lake Berryessa
R
Mokelumne R
Bodega Bay
PACIFIC OCEAN
Mono Lake
San Francisco Bay
Stanislaus R
San Joaquin River
Merced R
Owens River
Monterey Bay
Friant-Kern Canal
R
Kings
River
Owens Lake
Salinas R
Amargosa R
Kern
Buena Vista Lake
Lake Havasu
Colorado R
Santa Barbara Channel
Salton Sea
San Pedro Channel
Outer Santa Barbara Passage
Coachella Canal

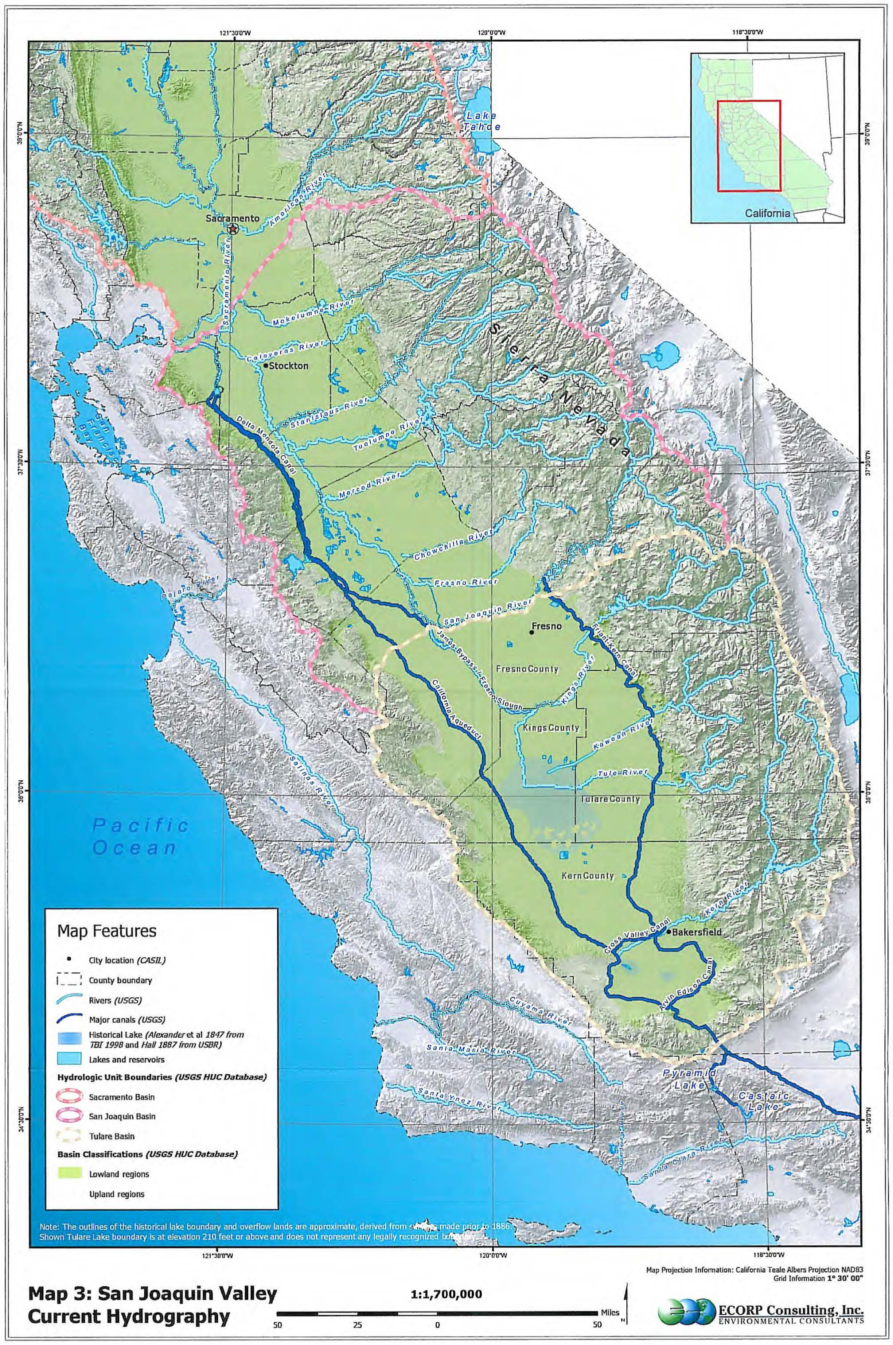
This map shows the major streams and rivers of California and some of the larger lakes. Most of California is in the Pacific Ocean watershed. Major streams that drain to the Pacific include the San Joaquin, Salinas, Russian, Eel and Trinity Rivers. Small parts of eastern California are in the Great Basin, an area of the United States that does not drain into any ocean but instead drainage flows into local basin such as Lake Tahoe or Mono Lake.

4.3 (3) Sierra Nevada Trip Overview — Major Stops & Land Designations


Park
National Forest
BLM Land
Military Land
State Park
Natural Area
Attraction
Main Street City
Major Airport
Rest Area
Ski Area
Wildlife Viewing Area
N
0
20 mi
Donner Summit 7,240'
Soda Springs
Truckee
Martis Creek Lake Rec Area
Norden
Donner Mem SP
Northstar
Kings Beach
Tahoe Vista
N Fork American River
Squaw Valley
Burton Creek SP
Olympic Valley
Tahoe City
Lake Tahoe
EL DORADO NF
Homewood
Tahoma
Sugar Pine Point SP
Meeks Bay
Loon Lake/Crystal Basin Rec Area
DL Bliss SP
Emerald Bay SP
South Lake Tahoe
Desolation Wild Area
Union Valley Reservoir
Meyers
Twin Bridges
S Fork American River
Kyburz
Pollock Pines
Echo Summit 7,382'
China Flat/Silver Fork Campground
Hope Valley WA
Kirkwood
Markleeville
Grover Hot Springs SP
Silver Fork Rd
Kit Carson
Carson Pass 8,560'
Monitor Pass 8,314'
Coleville
GOLD COUNTRY REGION
Mokelumne River
Ebbetts Pass 8,732'
Pacific Crest Trail
Walker
Bear Valley
(closed in winter)
TOIYABE NF
Cottage Springs
Sonora Pass 9,265'
NEVADA
CALIFORNIA
Dorrington
STANISLAUS NF
Leavitt Pk 11,569'
Bridgeport Reservoir
East Walker WA
Calaveras Big Trees SP
N Fork Stanislaus River
Pinecrest Lake
Bridgeport
Bodie
Bodie SHP
Arnold
Pinecrest
Dodge Ridge
Tower Pk 11,755'
Matterhorn Pk 12,264'
Mi-Wuk Village
Twain Harte
Tuolumne
Cherry Lake
Mono Lake
Lee Vining
Mono Basin National Forest Scenic Area
Lake Eleanor
Hetch Hetchy Reservoir
YOSEMITE NP
Tioga Pass 9,945'
Mono Lake Tufa SR
Tuolumne River
Lee Vining/Tioga Lake
Groveland
INYO NF
Benton
Half Dome 8,842'
Mt Lyell 13,114'
June Lake
Glass Mtn 11,123'
Yosemite Falls
Yosemite Village
Mt A Adams 11,760'
Hot Creek Wetlands & Fish Hatchery
El Portal
Merced River
Mammoth Lakes
White Mtn 14,246'
Badger Pass
Devils Postpile NM
Crowley Lake
Pioneer Yosemite History Center
Merced Pk 11,726'
Rainbow Falls
Laurel Ponds
Tom's Place
Wawona
SIERRA NF
Red Slate Mtn 13,163'
Fish Slough
Blanco Mtn 11,278'
Mariposa
Yosemite Mountain Sugar Pine Railroad
Fish Camp
Sierra Vista National Scenic Byway
130 miles to Monterey
San Joaquin River
Lake Thomas Edison
Mt Abbot 13,715'
Ancient Bristlecone Pine Forest
Wassama Round House SHP
Ahwahnee
Bass Lake
Mammoth Pool Reservoir
Bishop
Oakhurst
Mt Tom 13,652'
Huntington Lake
Lakeshore
High Sierra Rec Area
North Fork
Mt Powell 13,361'
Big Pine
Shaver Lake
SEQUOIA NF
North Palisade 14,242'
Tinemaha Reservoir
Split Mtn 14,058'
KINGS CANYON NP
Mt Pinchot 13,495'
CENTRAL VALLEY REGION
Pine Flat Reservoir
GIANT SEQUOIA NM
Kings River
Cedar Grove
Mt Whitney/Black Rock Hatcheries
Owens River
Owens Valley
Boyden Cavern
Independence
Grant Grove
University Pk 13,632'
Generals Hwy
Mt Williamson 14,375'
Sierra Nevada
Lone Pine
Mt Whitney 14,494'
DESERT REGION
Giant Forest
Mt Langley 14,042'
Cottonwood Cr
SEQUOIA NP
to Visalia
Kern River
Death Valley
Olancha Pk 12,123'
Western Divide Hwy
Sherman Pass Rd
Kennedy Meadows Rd
S Fork Kern River
Haiwee Deer Winter Refuge
California Hot Springs
Sierra Way
Kernville
Kern River Valley
Lake Isabella
Weldon
Bodfish
Havilah
Indian Wells Valley
Red Rock Canyon SP
110 miles to Los Angeles

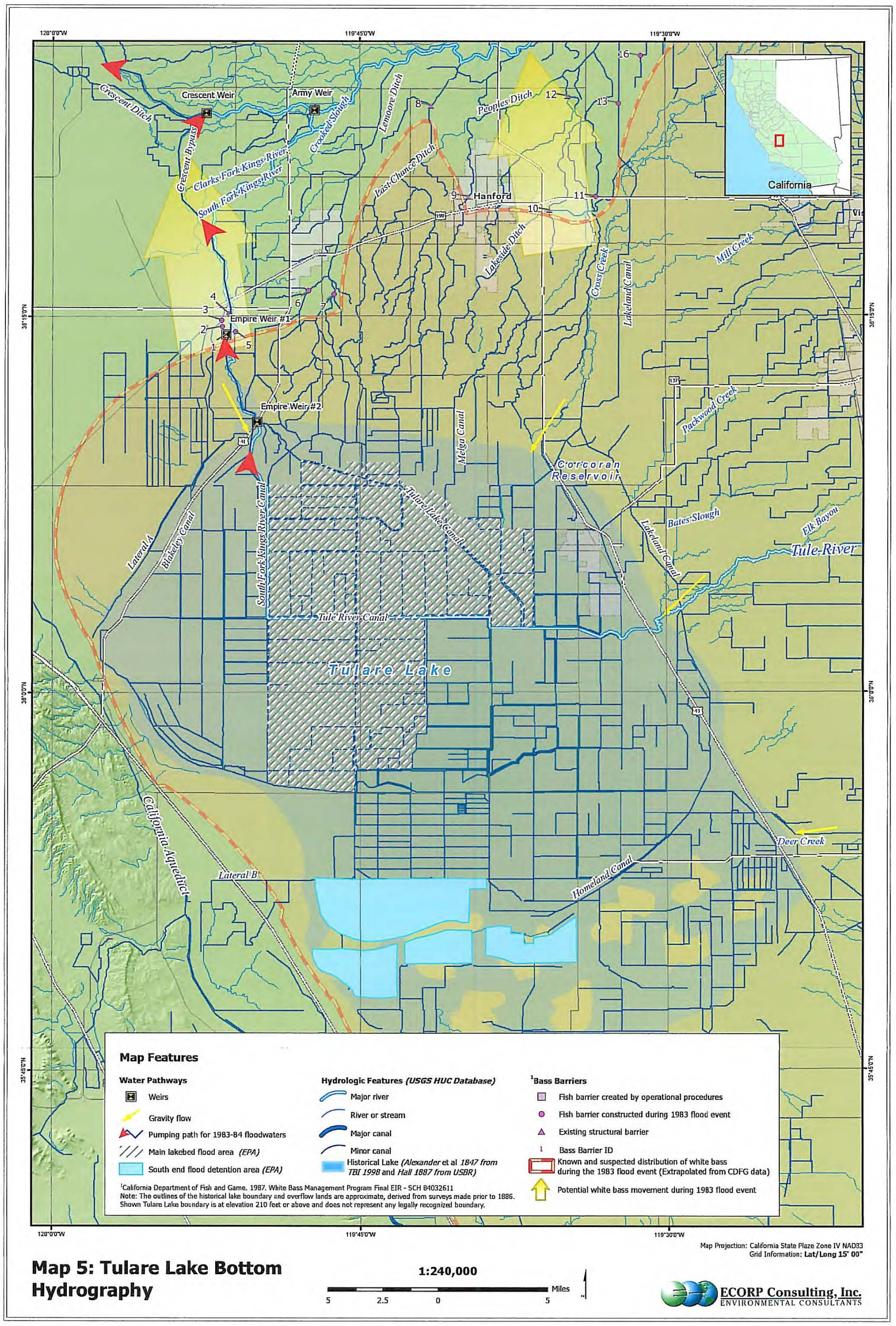
A regional overview of the route through the southern Sierra Nevada, showing our major stops against the patchwork of public-land designations the trip crosses: national parks and forests, BLM land, military land, state parks, and natural areas, along with attractions, towns, and recreation sites. The legend keys the colors and symbols. Note how much of the high country is federal land — national forest and park — while the valley and foothill stops sit on a mix of state, BLM, and private holdings.

4.4 (4) San Joaquin Valley Current Hydrography


121°30'0"W
120°0'0"W
118°30'0"W
39°0'0"N
37°30'0"N
36°0'0"N
34°30'0"N
California
Lake Tahoe
Sacramento
American River
Sacramento River
Mokelumne River
Calaveras River
Stockton
Stanislaus River
Tuolumne River
Merced River
Delta Mendota Canal
Sierra Nevada
Chowchilla River
Fresno River
San Joaquin River
Fresno
Fresno County
Kings River
Kings County
Kaweah River
Tule River
Tulare County
Kern County
California Aqueduct
Bakersfield
Kern River
Cross Valley Canal
Pacific Ocean
Salinas River
Cuyama River
Santa Maria River
Santa Ynez River
Santa Clara River
Pyramid Lake
Castaic Lake
Map Features
City location (CASIL)
County boundary
Rivers (USGS)
Major canals (USGS)
Historical Lake (Alexander et al 1847 from TBI 1998 and Hall 1887 from USBR)
Lakes and reservoirs
Hydrologic Unit Boundaries (USGS HUC Database)
Sacramento Basin
San Joaquin Basin
Tulare Basin
Basin Classifications (USGS HUC Database)
Lowland regions
Upland regions
Note: The outlines of the historical lake boundary and overflow lands are approximate, derived from surveys made prior to 1886.
Shown Tulare Lake boundary is at elevation 210 feet or above and does not represent any legally recognized boundary.
Map Projection Information: California Teale Albers Projection NAD83
Grid Information 1° 30' 00"
Map 3: San Joaquin Valley Current Hydrography
1:1,700,000
50
25
0
50
Miles
N
ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

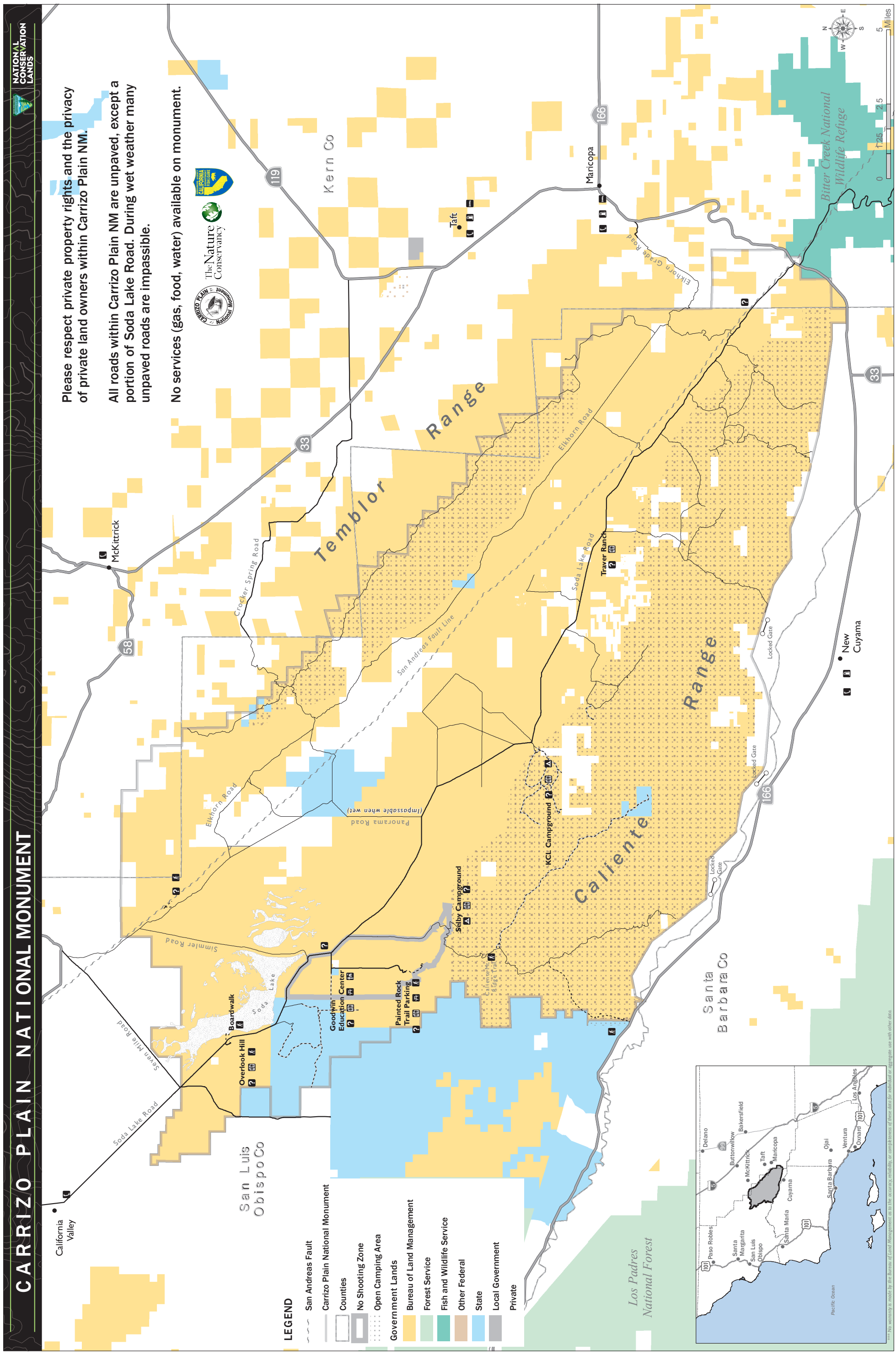
The modern San Joaquin Valley drains the western Sierra through a dense network of rivers and engineered canals. Sierran snowmelt is captured, stored, and redistributed for agriculture and cities across the Central Valley. Note the Tulare Basin in the south — a closed (endorheic) basin with no natural outlet to the sea.

4.5 (5) Tulare Lake Bottom Hydrography


120°0'0"W
119°45'0"W
119°30'0"W
36°15'0"N
36°0'0"N
35°45'0"N
Crescent Weir
Army Weir
Crescent Ditch
Crescent Bypass
Clarks Fork Kings River
South Fork Kings River
Crooked Slough
Lemoore Ditch
Peoples Ditch
Last Chance Ditch
Hanford
Lakeside Ditch
Cross Creek
Lakeland Canal
Mill Creek
Empire Weir #1
Empire Weir #2
Melga Canal
Corcoran Reservoir
Packwood Creek
Bates Slough
Elk Bayou
Tule River
Tulare Lake Canal
South Fork Kings River Canal
Blakeley Canal
Lateral A
Tule River Canal
Tulare Lake
Deer Creek
Homeland Canal
Lateral B
California Aqueduct
California
1
2
3
4
5
6
8
9
10
11
12
13
16
Map Features
Water Pathways
Weirs
Gravity flow
Pumping path for 1983-84 floodwaters
Main lakebed flood area (EPA)
South end flood detention area (EPA)
Hydrologic Features (USGS HUC Database)
Major river
River or stream
Major canal
Minor canal
Historical Lake (Alexander et al 1847 from TBI 1998 and Hall 1887 from USBR)
¹Bass Barriers
Fish barrier created by operational procedures
Fish barrier constructed during 1983 flood event
Existing structural barrier
Bass Barrier ID
Known and suspected distribution of white bass during the 1983 flood event (Extrapolated from CDFG data)
Potential white bass movement during 1983 flood event
¹California Department of Fish and Game. 1987. White Bass Management Program Final EIR - SCH 84032611
Note: The outlines of the historical lake boundary and overflow lands are approximate, derived from surveys made prior to 1886. Shown Tulare Lake boundary is at elevation 210 feet or above and does not represent any legally recognized boundary.
Map Projection: California State Plaze Zone IV NAD83
Grid Information: Lat/Long 15' 00"
Map 5: Tulare Lake Bottom Hydrography
1:240,000
5
2.5
0
5
Miles
N
ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

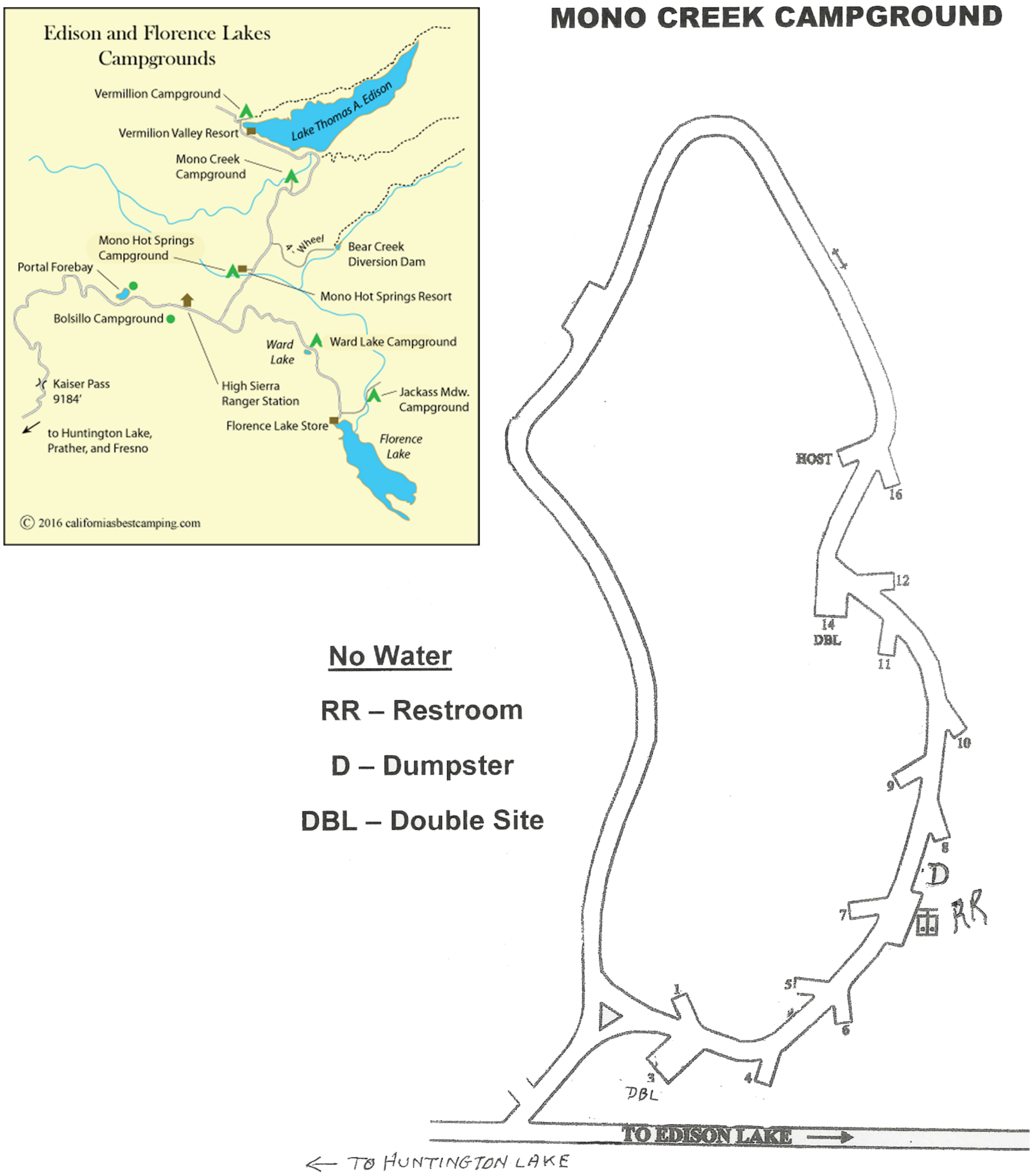
Tulare Lake was once the largest freshwater lake west of the Mississippi, fed by the Kern, Kings, Kaweah, and Tule rivers. Diversion of those rivers for irrigation drained the lakebed by the early 20th century, though it briefly refills in extreme wet years (most recently 2023). The map shows the historic lake margin, weirs, and the canal network that now manages its floodwaters.

4.6 (6) Carrizo Plain & the San Andreas Fault


CARRIZO PLAIN NATIONAL MONUMENT
NATIONAL CONSERVATION LANDS
Please respect private property rights and the privacy of private land owners within Carrizo Plain NM.
All roads within Carrizo Plain NM are unpaved, except a portion of Soda Lake Road. During wet weather many unpaved roads are impassible.
No services (gas, food, water) available on monument.
The Nature Conservancy
Temblor Range
Caliente Range
Kern Co
San Luis Obispo Co
Santa Barbara Co
McKittrick
Taft
Maricopa
New Cuyama
California Valley
Traver Ranch
KCL Campground
Selby Campground
Painted Rock Trail Parking
Goodwin Education Center
Boardwalk
Overlook Hill
Soda Lake
Soda Lake Road
Seven Mile Road
Simmler Road
Panorama Road
(Impassible when wet)
Elkhorn Road
Crocker Spring Road
Elkhorn Grade Road
San Andreas Fault Line
Locked Gate
Bitter Creek National Wildlife Refuge
Los Padres National Forest
33
58
119
166
LEGEND
San Andreas Fault
Carrizo Plain National Monument
Counties
No Shooting Zone
Open Camping Area
Government Lands
Bureau of Land Management
Forest Service
Fish and Wildlife Service
Other Federal
State
Local Government
Private
0 1.25 2.5 5 Miles
Bakersfield
Delano
Buttonwillow
Paso Robles
Santa Margarita
San Luis Obispo
Santa Maria
Cuyama
Ojai
Ventura
Oxnard
Santa Barbara
Los Angeles
Pacific Ocean

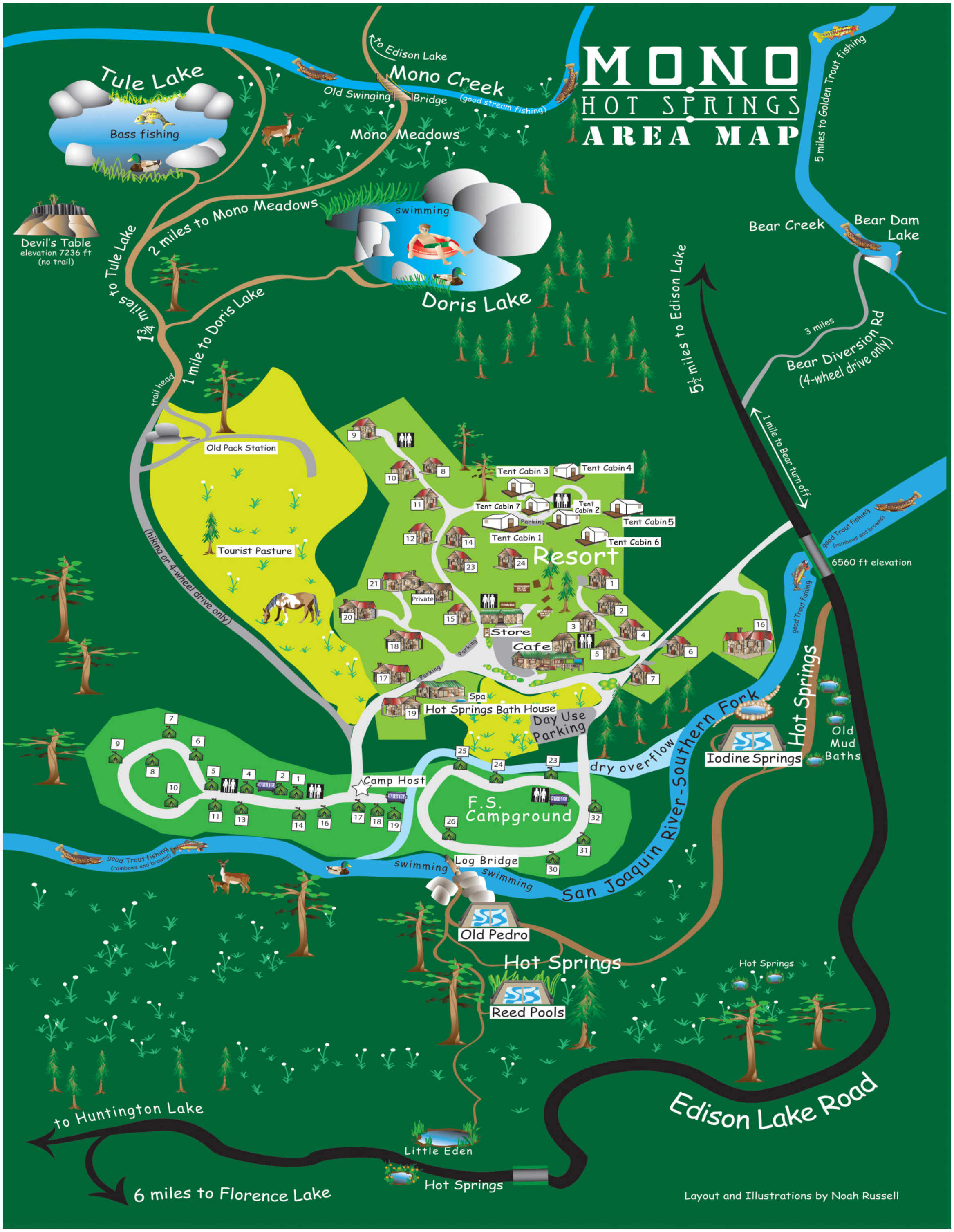
The Carrizo Plain preserves one of the clearest surface expressions of the San Andreas Fault, where the Pacific and North American plates grind past one another. Offset stream channels here record meters of slip from past great earthquakes, including the 1857 Fort Tejon event. The semi-arid plain is also one of California's largest remnant native grasslands.

4.7 (7) Mono Creek Campground (Night 1)


Edison and Florence Lakes Campgrounds
Vermillion Campground
Vermilion Valley Resort
Lake Thomas A. Edison
Mono Creek Campground
Mono Hot Springs Campground
Portal Forebay
4-Wheel
Bear Creek Diversion Dam
Mono Hot Springs Resort
Bolsillo Campground
Ward Lake
Ward Lake Campground
Kaiser Pass 9184'
High Sierra Ranger Station
Jackass Mdw. Campground
Florence Lake Store
Florence Lake
to Huntington Lake, Prather, and Fresno
© 2016 californiasbestcamping.com
MONO CREEK CAMPGROUND
No Water
RR – Restroom
D – Dumpster
DBL – Double Site
HOST
16
12
14
DBL
11
10
9
8
D
RR
7
5
6
1
3
DBL
4
TO EDISON LAKE
TO HUNTINGTON LAKE

Our group holds sites **001, 003, 004, 005, and 006** at Mono Creek Campground for the Night 1 stay. Use this map to find your assigned site and the shared facilities (water, restrooms, bear lockers). Please keep all food and scented items in the bear-proof storage.

4.8 (8) Mono Hot Springs


MONO HOT SPRINGS AREA MAP
Tule Lake
Bass fishing
Devil's Table elevation 7236 ft (no trail)
to Edison Lake
Mono Creek
Old Swinging Bridge
(good stream fishing)
Mono Meadows
5 miles to Golden Trout fishing
Bear Creek
Bear Dam Lake
swimming
Doris Lake
2 miles to Mono Meadows
1¾ miles to Tule Lake
1 mile to Doris Lake
trail head
5½ miles to Edison Lake
3 miles
Bear Diversion Rd (4-wheel drive only)
1 mile to Bear turn off
Old Pack Station
Tourist Pasture
(hiking or 4-wheel drive only)
Tent Cabin 3
Tent Cabin 4
Tent Cabin 7
Tent Cabin 2
Tent Cabin 5
Tent Cabin 1
Tent Cabin 6
Parking
Resort
Private
Store
Cafe
Spa
Hot Springs Bath House
Day Use Parking
good Trout fishing (rainbows and browns)
6560 ft elevation
Hot Springs
Old Mud Baths
Iodine Springs
Southern Fork
dry overflow
Camp Host
F.S. Campground
San Joaquin River
Log Bridge
swimming
Old Pedro
Hot Springs
Reed Pools
to Huntington Lake
6 miles to Florence Lake
Little Eden
Hot Springs
Edison Lake Road
Layout and Illustrations by Noah Russell

An optional evening soak a short drive from camp. Note that Mono Hot Springs charges **$25 per person**, which **will not be covered by the department** — this is an out-of-pocket cost should you choose to go. The map shows the developed pools, the resort, and parking.

5 Talks

— *Colonel Allensworth State Historic Park* —

(1) Colonel Allen Allensworth: From Slavery to Town Founder — *Nick Anderson*

Colonel Allen Allensworth – Me!

"The substance, not the shadow" — an escaped slave who built a free Black town in the San Joaquin Valley

Chaplain Allen Allensworth U.S.A.
Fort Bayard
N.M.
Jan 15-89.
Elrod
LOUISVILLE, Ky.

Lt. Col. Allen Allensworth in uniform, c. 1900
(public domain; California State Archives / U.S. National Archives).

Allen Allensworth (1842–1914) was an American chaplain, Army officer, theologian, and town founder. Born into slavery in Kentucky, he freed himself during the Civil War by joining a Union regiment, later became a Baptist minister and teacher, and in 1886 was appointed an Army chaplain to a Buffalo Soldier regiment — ultimately becoming the **first African American to reach the rank of lieutenant colonel** in the U.S. Army. After retiring in 1906 he led the founding of **Allensworth, California** (1908), the first town in the state established, financed, and governed entirely by African Americans, now preserved as Colonel Allensworth State Historic Park.

1842	1886	1906	1908	1914
Born enslaved	Army chaplain	Lt. colonel	Founds town	Dies

Early life and Slavery

Allensworth was born in Louisville, Kentucky, on April 7, 1842, the youngest of thirteen children of Phyllis and Levi Allensworth. The family was scattered by sale: several brothers were sent downriver to Deep South plantations, while one sister escaped to Canada on the Underground Railroad. Assigned as a boy to wait on his enslaver's son, Allen began learning to read alongside him — illegal under Kentucky law. When his owners discovered this, he was moved between households and, after a kind Quaker woman kept teaching him, was sent downriver in 1854 to break the habit. Sold again through Memphis to New Orleans, he was bought by a horseman who valued his literacy and made him an exercise boy and jockey. He attempted escape more than once and was repeatedly punished and re-sold.

Military Service

In 1862, while racing brought him back to Louisville, Allensworth slipped away with soldiers of the 44th Illinois Volunteer Infantry, marching past his former enslaver to freedom. He served first as a civilian nursing aide, then enlisted in the U.S. Navy on April 3, 1863 earning his first wages as a free man — rising to captain's steward and clerk aboard Union gunboats.

Education and ministry

After the war he studied at the Ely Normal School and taught in Freedmen's Bureau schools during Reconstruction. Ordained a Baptist minister in 1871, he studied theology in Tennessee and led several congregations, reorganizing Louisville's Harney Street church (renamed Centennial Baptist) and growing it nearly fivefold. He helped found what became Simmons College of Kentucky.

Marriage and family

In 1877 he married Josephine Leavell (1855–1938), an accomplished pianist and organist he met at Roger Williams University in Nashville. They had two daughters, Eva and Nella. He brought his mother Phyllis to live with them; she died in 1878.

Politics

As his reputation as a leader and orator grew, Allensworth served as Kentucky's only Black delegate to the Republican National Conventions of 1880 and 1884.

Army chaplain: the Buffalo Soldiers

In 1886, with backing from politicians of both regions, Allensworth was appointed an Army chaplain by President Grover Cleveland and assigned to the 24th Infantry Regiment, one of the segregated Buffalo Soldier units. His family followed him to posts including Fort Bayard (New Mexico), Fort Supply (Indian Territory), Fort Douglas (Utah), and Fort Harrison (Montana); Josephine played organ in the fort chapels. In 1889 he published an Outline of Course of Study and Rules Governing Post Schools that became a military education standard. By his retirement in 1906 he had risen to lieutenant colonel — the first African American to hold that rank in the U.S. Army.

Founding Allensworth

Settling in Los Angeles, Allensworth set out to build a self-governing Black community free of post-Reconstruction discrimination — a place, in his words, to foster "sentiment favorable to intellectual and industrial liberty." By 1908, with William Payne and a small committee, he founded Allensworth in Tulare County, about thirty miles north of Bakersfield. Residents built homes, laid out streets, and raised a church, an orchestra, a glee club, and a brass band. It was the only California town founded, financed, and governed by African Americans, and elected the first African American Justice of the Peace in post-Mexican California. An admirer of Booker T. Washington, Allensworth dreamed his colony would become a "Tuskegee of the West"; its streets were named for Sojourner Truth, Frederick Douglass, Paul Laurence Dunbar, and Harriet Beecher Stowe.

Decline

Several blows undid the town. Allensworth's death in 1914 removed its central leader; a dropping water table left it chronically short of water; the Great Depression and World War II drew residents elsewhere; and arsenic found in three wells in 1965 led to a 1966 demolition order.

Death

Allensworth died at 72 on September 14, 1914, struck by a motorcyclist in Monrovia while on his way to speak. He is buried at Angelus-Rosedale Cemetery in Los Angeles. Charles Alexander published his biography, Battles and Victories of Allen Allensworth, that same year.

Legacy and honors

About 240 acres of the townsite became Colonel Allensworth State Historic Park, part of the state park system since 1973. The prized schoolhouse, used until 1972, is furnished as it would have appeared on a school day in 1915, and his residence is preserved in 1912-period style. The park holds an annual re-dedication ceremony, and a public monument to Allensworth, designed by Ron Husband, stands in Monrovia.

> *"All laws against us are merely public opinion in legal forms." – Col. Allen Allensworth*
>
> Allensworth sits on the old Tulare Lake bed, and the arsenic that finally poisoned the town's wells is part of the very same closed-basin water chemistry we follow all of Day 1 — from the San Joaquin's diverted rivers to the dust of the Carrizo Plain. The town's rise and fall is, at root, a water story.

(3) Boswells, Resnicks and Singletons — California's Billionaire Farmers — *Olivia Alcabes*

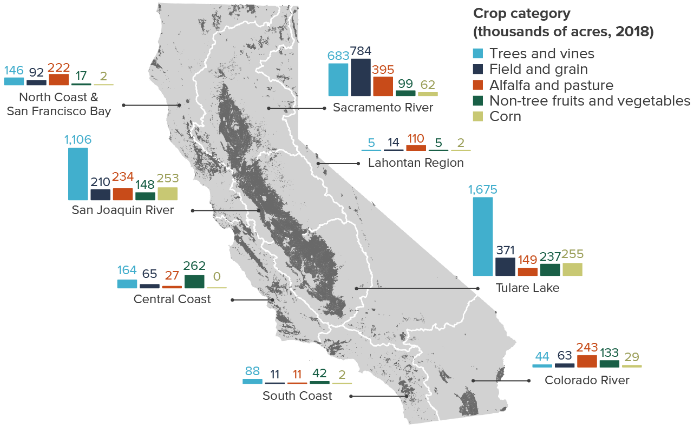
California Agricultural Land Ownership

Olivia Alcabes

The History & Trajectory of Agriculture in the US

Over the course of the 20th century, farming in the US underwent a transformation as more and more agricultural production became centralized in larger facilities as opposed to traditional family farms that produced a number of different crops and livestock goods (Dimitri et. al. 2005). This trend is only expected to continue (Calo & Song 2025).

California Farmland


Crop category
(thousands of acres, 2018)
Trees and vines
Field and grain
Alfalfa and pasture
Non-tree fruits and vegetables
Corn
146 92 222 17 2
North Coast & San Francisco Bay
683 784 395 99 62
Sacramento River
5 14 110 5 2
Lahontan Region
1,106 210 234 148 253
San Joaquin River
1,675 371 149 237 255
Tulare Lake
164 65 27 262 0
Central Coast
44 63 243 133 29
Colorado River
88 11 11 42 2
South Coast

California is one of the top agricultural-producing states. For example, Fresno County is the #1 county by agricultural sales in the nation. 40 million acres of land in California (40% of the total land) is used for agriculture. Fig. 1 (to the right, Cole et. al. 2024) shows the breakdown of crop category by type in different California agricultural regions. "Field and grain" and "Alfalfa and pasture" categories refer to animal farming (alfalfa is very common feed for cows), whereas "Trees and vines," "Non-tree fruits and vegetables," and "Corn" are plant based farms. However, information about who owns California's farmland is often opaque, even though it is technically required to be open to the public (Calo & Song 2025). Looking at land ownership involves scouring tons of parcel-level data. Often, the ownership reported by land parcels are shell companies and trusts, hiding the information about the larger corporations or individuals that own said companies and trusts.

The Resnicks, The Boswells, – are they the real problem?

You may be familiar with the names Stewart and Lynda Resnick from the new Caltech campus building. They own the Wonderful Company, a $6 billion dollar company that includes Wonderful pistachios, POM pomegranate juice, Fiji bottled water, and Halo mandarins ("Who are the Resnicks" 2025). Lynda Resnick appears to be a marketing genius – she commissioned the studies looking at the health benefits of pomegranates, which led to the huge trend behind buying POM pomegranate juice. During the fires of January 2025, criticism circulated online about billionaire farmland owners of California, and how they might have contributed to water shortages. Henry (2025) from SJV Water, an independent, nonprofit news site covering water in the San Joaquin Valley, published an article in the Fresno Bee about the Resnicks. He notes that the Resnicks don't own anywhere near 60 or 70% of California's water, as some people were claiming after the big fires last year, and none of their water would have been used for Los Angeles municipalities anyways. In fact, the Resnicks are not even the largest family farmland owners in California. Actually, the Boswell Family farm, which primarily produces tomatoes and is based in Pasadena, owns 207,000 acres (Dillard 2026). Stewart and Lynda Resnick own 196,775 acres. The third largest farm family in CA is the Singleton family, which owns 171,000 acres. While this is a lot of land, comparing these numbers with the total acreage of California farmland (remember, 40 million!!), it becomes clear that while they have a lot of power, they are nowhere close to owning the majority of farmland in California.

POM
WONDERFUL
ANTIOXIDANT SUPERPOWER
100% POMEGRANATE JUICE
16 FL OZ (473 ml)
from concentrate

There Are Much Larger Agricultural Owners in California (and Some Of Them Might Surprise You)

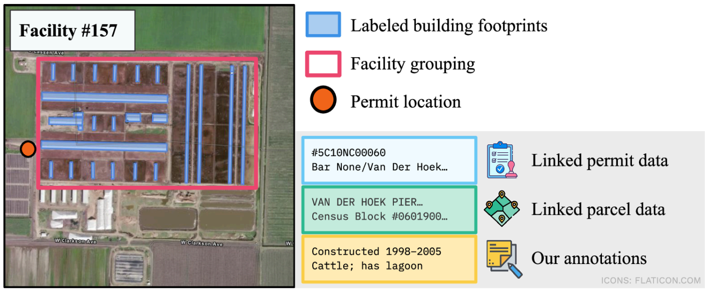
Calo & Song (2025) from the SF Chronicle found that in Fresno County, the largest 105 of owners hold 73% of the farmland. In King's County, they own 86%, or approximately 717,000 of 827,000 acres. Small owners, i.e. farmers who own less than 50 acres of land, own less than 10% of the state's cropland as of 2018. They write that "our research showed that agribusiness, insurance companies, real estate investment firms, and private trusts are the top landowners in California." If we compare these numbers to the numbers of the individual families listed above, it becomes clear that while there are individuals who own a lot of land, the largest landowners in the US are *not* individuals or families, but instead corporations. Calo & Song (2025) illustrate this with clear examples. Notably, they find that Chevron is the fifth-largest owner of agricultural land in the Central Valley. They also note that an investment branch of the Church of Jesus Christ of Latter-day Saints is in the top 20 agricultural land owners in the Central

Valley. However, they hesitated to remark on the other landowners and I couldn't find a released list, which may be due to the opaqueness surrounding these land ownership records.

Environmental Effects of Corporate Agriculture Ownership

Having large corporate ownership of farmland can have a major impact on the environment and surrounding communities. Corporations are more likely to employ harmful practices such as monocropping, chemical pesticides, fertilizers, and overpumping groundwater (Calo & Song 2025). They find that investment firms and asset management companies can own farmland, and they are solely interested in maximizing shareholder profits rather than caring about local sustainability the way a smaller farmer would.

Animal agriculture in particular has significant environmental effects. In California, a majority of animal agriculture is beef and dairy farms, in large Concentrated Animal Feeding Operations or CAFOs. See an example of such a farm to the right in Fig. 2 (Magesh et. al. 2025). CAFOs are more likely to be owned by corporations than by small-scale farmers. There is a very small amount of square footage per animal in a CAFO, and CAFOs have significant environmental effects. First, CAFOs produce large amounts of animal waste, which has been shown to greatly affect nearby water quality (Hooda et. al. 2000; Hornbuckle 2006; Raff & Meyer 2016; Waller et. al. 2021). Water bodies nearby CAFOs tend to have increased levels of nutrients (Miralha et. al. 2022), which can greatly impact nutrient cycles (Hooda et. al. 2000) and cause thousands of dollars in damage (Raff & Meyer 2016). CAFOs are also a major source of anthropogenic methane emissions. CAFOs produce methane emissions through enteric fermentation and manure management (US EPA 2024), and cows are the largest emitters. Beef cattle account for 72% of all livestock enteric fermentation, dairy cows account for 25%, and other animal types emit the rest.



Policy Solutions

Song & Calo note that there are examples of policy measures around the world that can combat the growth of large scale corporate ownership of agricultural land. In Scotland, there are landreform laws for "right of refusal and tenant right-to-buy programs" that allow land to remain under local control. They also note that property taxes can be used to limit corporate monopolies. However, it is difficult to know which policies might work the best in California when it remains so opaque who owns what. They note that the EU has announced a "euro-land observatory pilot" which creates an inventory of farms and who profits from them, and doing something similar in California would be one of the first steps to understanding more about how corporate interests in CA are influencing our food systems.

The issue of lack of data surrounding farmland is heightened for animal agriculture. Even with the high potential for environmental and financial consequences, CAFOs are notoriously difficult to regulate due to the lack of available data about them, even in regions where significant environmental policy has been passed (Mittal 2009). Technology may help with this in the future. A number of studies have demonstrated how deep learning can be used to detect and estimate the size of CAFOs, and Magesh et. al. (2025) have published data of detected CAFOs in California.

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— *San Joaquin Hatchery* —

(4) What Happens at a Fish Hatchery? Life Cycle of a Salmonid — *Amelie Sharples*

What Happens at a Fish Hatchery? San Joaquin Fish Hatchery (+ the life cycle of fish)

Why do we care about fish?

Fish are an essential ingredient to maintaining a balance in the watershed food web. Predators ranging from birds and foxes to coyotes and bobcats to raccoons and river otters all depend on fish to survive. When these predators die, they are eventually returned to the ecosystem, providing the river with essential nutrients that come back to feed the fish. Humans have placed a massive block in this harmonious cycle. With overfishing, chemical and thermal pollution of rivers, and extensive damming, the fish populations of California have dropped dramatically in the past few decades.

Salmon specifically are considered a keystone species – i.e. they have a disproportionately large effect on the broader natural environment [1]. California banned the fishing of salmon from 2023 until 2026 due to alarming low salmon levels (the salmon levels over the past decades have ranged around 6,000 instead of historical estimates of 600,000 – that's 1%!), which marked the longest shutdown of salmon fishing in California history [2]. Other species are also being actively harmed from the reduce in fish populations – for example, where I'm from around Seattle, the local orca population is now endangered, and one of the three main causes is due to decreased fish populations look up the Southern Resident Killer Whales!). California state agencies have now instated a Salmon Strategy ("For a Hotter, Drier Future") that involves removing barriers, protecting salmon habitats, water quality, and modernizing **hatcheries**. It is viewed as not only a solution to bringing back salmon populations, but to other species of fish and entire aquatic ecosystems as a whole.

What is a fish hatchery? Why is it VERY different from fish farming?

Fish hatcheries are built for the purpose of reviving fish populations in local rivers [3]. Fish farming is rather a way of producing salmon for human consumerism. Fish farms can be incredibly toxic, facilitating the spread of diseases and parasites and often facing over population, with methods of slaughter sometimes being completely inhumane. Meanwhile, fish hatcheries are built with the purpose of reintroducing fish into the marine ecosystem. The fish are born and raised initially within the hatchery, and they are then released into the wild to repopulate regions where fish populations have been on the decline. While hatcheries are nowhere near perfect, with concerns specifically raised on the disruption of ecosystem balance and competition with the local native species, they have become absolutely vital to preventing the total extinction of fish populations such as the California salmon.

History of the San Joaquin Hatchery

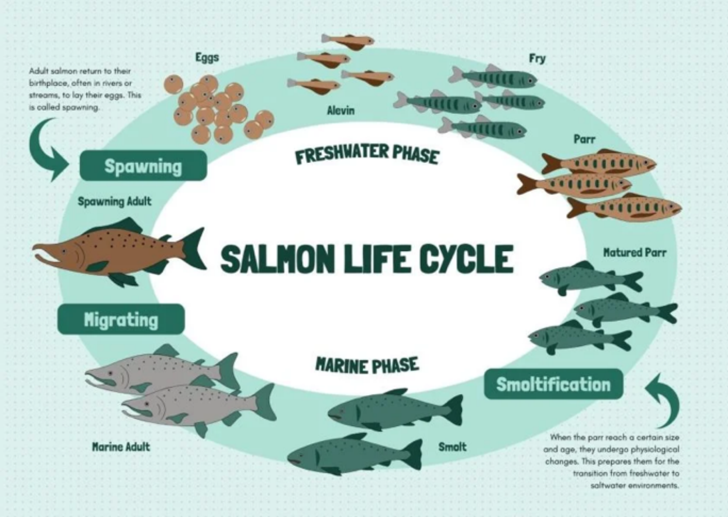
Fish hatcheries are key to the preservation and conservation of fish in rivers and oceans. While reintroducing fish to ecosystems, they also operate on the goal of spreading awareness to the public about the important role fish play in our ecosystem. The first hatchery in the US was established in New York in 1864, successfully reviving trout populations on the east coast and remaining operational to this day [4]. The first hatchery in the San Joaquin river valley was built back in 1921, in response to the loss of spawning grounds after the Kerckoff Dam was completed. This hatchery was shut down rapidly due to travel difficulties, and the next one was built soon after in 1928, named the Kings River

Hatchery [5]. This remained operational until 1954, when resources were redirected primarily to the San Joaquin Hatchery which began in 1948 and continues to be operational [5].

The San Joaquin Hatchery is below the Friant Dam that creates Millerton Lake, and it redirects this lake water for stable conditions to grow the fish. The first two years of the hatchery were dedicated to experiments testing whether fish were able to successfully grow with the lake water, and now the facility has a total of 48 ponds to raise trout and salmon [5]. It hatches and raises millions of fish a year to stock the lakes and rivers throughout central California. In order to remain similar to wild conditions, hatcheries will often release the fish on seasonal timescales to match wild fish behavior, either releasing them as smolt that are ready to enter the ocean or in the earlier stage of life as fry in their native river habitat. The fish specifically released by this hatchery are primarily Golden Trout (which is the California state fish, inhabits the high mountain lakes in the sierras, has bright red and gold coloring, and is a subspecies of rainbow trout), as well as Kokanee (otherwise known as Sockeye Salmon that stays land locked, turning deep red during spawning), and Eagle Lake Trout (a specific strain of rainbow trout adapted for high pH waters and known for rapid growth).

Life Cycle of Fish!

This is hard to generalize to all fish, as some remain in the river while others go out to the ocean and return to the river to spawn. Upon returning to the river, some proceed to die while others will make the trip several times back to the river and the ocean throughout their lives. The general picture of a fish life cycle is as follows: they are born from fish eggs (1-10mm in diameter) in the river, whee they hatch as “alevin,” which rely on the attached yolk sac in their egg for food. Once this food supply has been depleted, they graduate to the term “fry” [6]. The fry feed on phytoplankton and zooplankton, which are nutrient rich, until they become smolts (also called fingerlings, several inches in length). After several months of feeding, they become “parr”, ready to separate from the school of fish, grow individuality, and once they reach the size of “smolt” after another few months to a year they are ready to venture out into the ocean (if they are ocean-goers) [6]. Depending on the species, fish can spend up to several years out at sea before coming back to their birthing grounds. After fighting their way up the river to lay their eggs, the Pacific salmon die and return their bodies and nutrients back to the environment.



Adult salmon return to their birthplace, often in rivers or streams, to lay their eggs. This is called spawning.

When the parr reach a certain size and age, they undergo physiological changes. This prepares them for the transition from freshwater to saltwater environments.

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(5) Vernal Pools — A Disappearing Ecosystem — *Sarah Davis*

Vernal Pools: a disappearing ecosystem

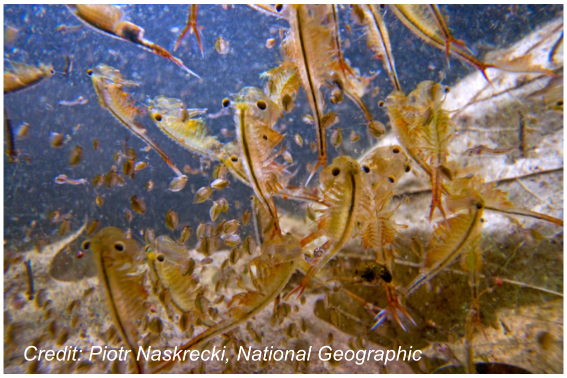
Sarah Davis – Ge 136C

What are Vernal Pools?

Vernal pools, also referred to as ephemeral pools, are seasonal wetlands that form in depressions in the land. They vary in size – ranging from puddles to ponds. During the wet season (typically winter through spring), the depressions fill with water from rain or snowmelt. During the dry season, the pools will often dry out completely.

Vernal Pool Fauna

Though the habitat is naturally disappearing and reappearing throughout the year, a substantial number of faunal species, known as obligate or indicator species, rely on these pools in order to maintain their lifecycles. Because vernal pools typically reoccur in the same location every year, many animals will actually return to the same pool they were born in to breed [1]. These ecosystems are also protectors of native life. Migratory birds seek refuge at vernal pools, amphibians lay their delicate eggs in the water, and many other animals utilize this essential microecosystem.


Credit: Piotr Naskrecki, National Geographic

Credit: Charlie Eichelberger

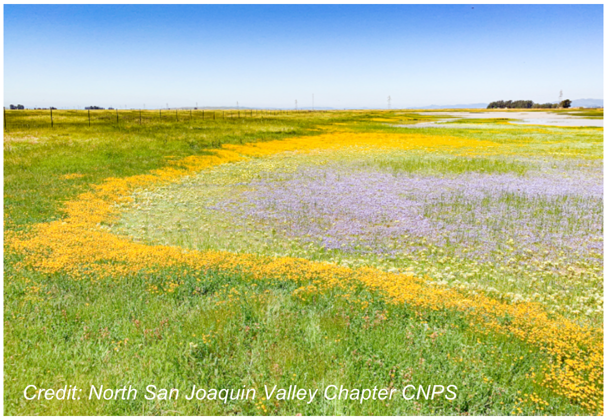
Credit: Ed Thompson

Fairy shrimp (see above, left) are major residents of vernal pools – resilient against harsh, dry conditions. As their name implies, they are also quite magical. If the vernal pool dries up, the shrimp can enter a state of dormancy – tucking themselves away within tiny cysts in the underlying soil. This long pause in which the shrimp are trapped in dried soil can last for years until the pool refills, thus releasing the sleeping beauties [2].

Amphibians, like the Jefferson salamander (*Ambystoma jeffersonianum*) (see above, right) are also indicator species that rely on vernal pools, not only as a water source for their eggs, but as a relatively predator-free safe haven for this part of their lifecycle [1,2].

Vernal Pool Flora

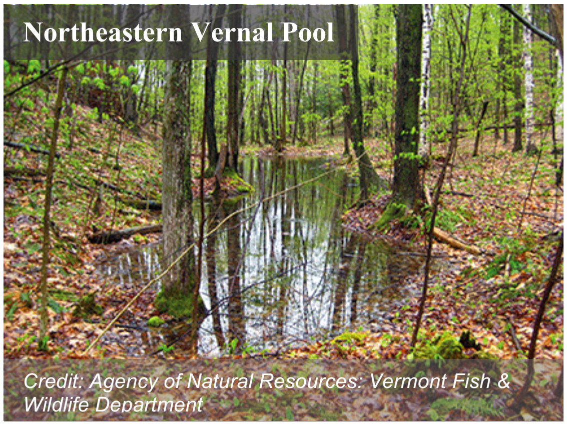
Flora is somewhat limited in vernal pools due to the habitats' unpredictable, yet extreme conditions (i.e., very wet or very dry). During the spring, Californian vernal pools can be identified by a circle of flowers that bloom in circles around the waterline of the pools as they dry (see right). However, plants like Colusa grass (*Neostapfia colusana*) that inhabit this special ecosystem are continuously threatened by the decreasing number of vernal pools due to anthropogenic expansion [3].


Credit: North San Joaquin Valley Chapter CNPS

Where do vernal pools form?

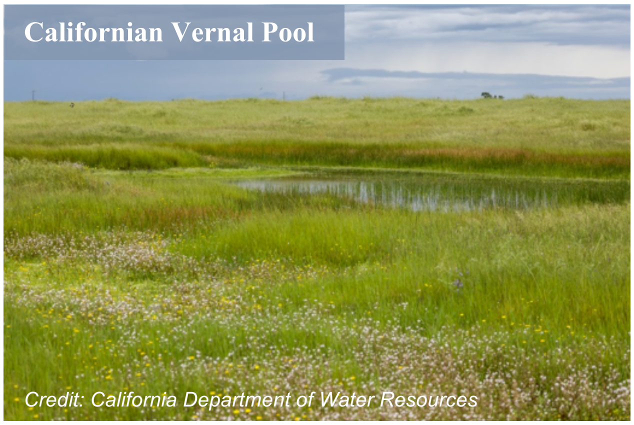
Northeastern vernal pools are numerous. Because the Northeastern United States was once heavily glaciated during the Last Glacial Maximum (LGM) 19 – 26ka, natural depressions exist in the landscape. Depressions can exist as kettle-holes – a result of buried ice from glacial outwash melting over time [4]. They can also exist due to the movement of glaciers carving gashes into the landscape. Additionally, because vernal pools require low-permeability material to maintain their water, fine to coarse-grained glacial till acts as an excellent underlying layer [5].

Western (Californian) vernal pools are concentrated in San Joaquin Valley [6], where low-lying land between the Sierra Nevada and Coast Ranges hold water as it rains or snowmelt runs off the mountains. Appearances may differ significantly between vernal pools in the eastern and western US (see images below), but both isolated freshwater wetlands are absolutely essential to local and global ecosystems.



Northeastern Vernal Pool

Credit: Agency of Natural Resources: Vermont Fish & Wildlife Department



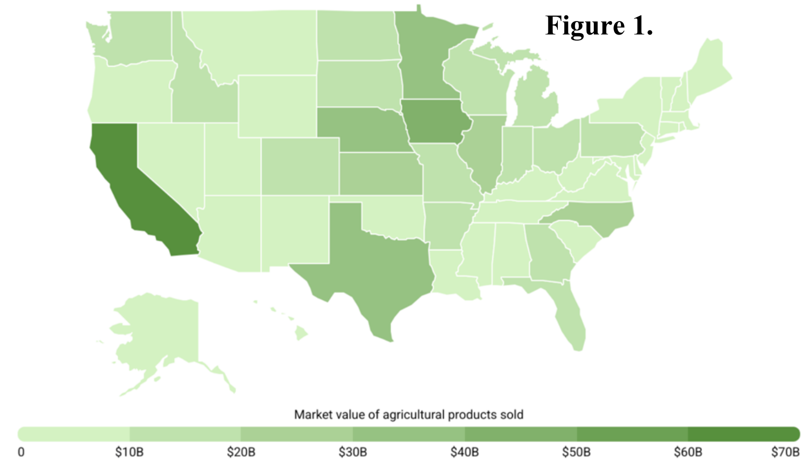
Californian Vernal Pool

Credit: California Department of Water Resources

Why are vernal pools disappearing?

San Joaquin Valley and, in general, the state of California is essential to agriculture in the United States (Figure 1). However, the industry is experiencing crushing demand with limited water and resources. Due the resulting expansion of residential and farming development, more than 90% of California’s vernal pools have disappeared (7). The temporal nature of vernal pools means that this ecosystem is generally overlooked when implementing environmental protection laws, especially when it comes to legally defining what a “water” is.

Figure 1.



Source: Farm Flavor analysis of USDA Census of Agriculture data

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Big Creek Hydroelectric Project

Marisa Langley

Overview

The Big Creek Hydroelectric Project is a largescale system for generating hydroelectric power located in the Sierra Nevada. Constructed over the course of the 20th century, the system is run by Southern California Edison (SCE) and it is a dependably provides over 3 million megawatt-hours of power annually [2]. Broadly, the Big Creek Hydroelectric project generates electricity by converting the potential energy into electrical energy. As in a typical hydroelectric dam system, water is kept inside of a reservoir at a high elevation and is allowed to move downwards while rotating a turbine which is hooked to a power generator, as in the following schematic:

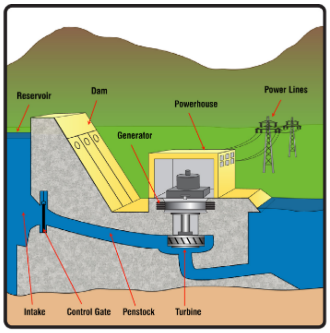

Reservoir
Dam
Powerhouse
Power Lines
Generator
Intake
Control Gate
Penstock
Turbine

Figure 1: How dams and turbines work together to generate power
Figure credit: [11].

More specifically, the Big Creek system, which was originally designed by the legendary engineer John Eastwood, consists of a series of water reservoirs from which water is channeled downstream through tunnels into powerhouses with turbines and generators. On the left is a map of the reservoirs, as well as the tunnels and powerhouses that make up the system:

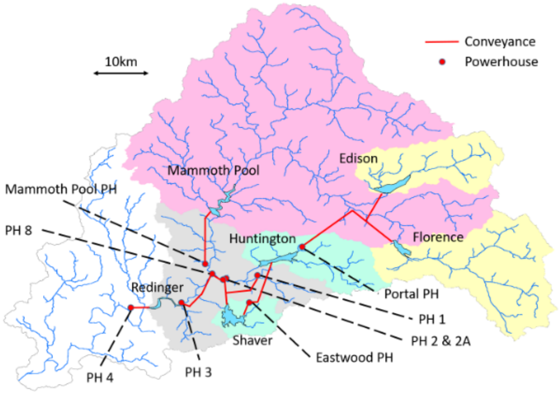
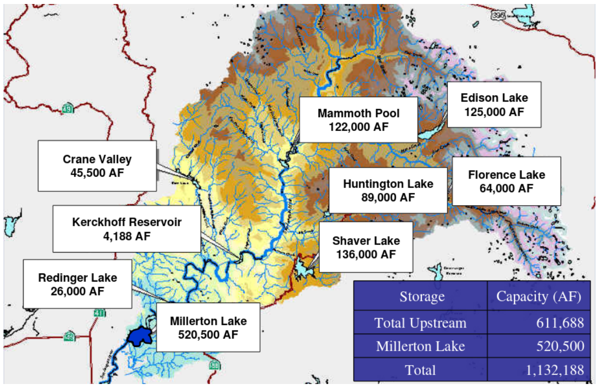

Conveyance
Powerhouse
10km
Mammoth Pool
Edison
Mammoth Pool PH
PH 8
Huntington
Florence
Redinger
Portal PH
PH 1
PH 2 & 2A
Shaver
Eastwood PH
PH 4
PH 3

Figure 2: The Big Creek system, with the tunnels and powerhouses indicated in red. Figure credit: [1].


Mammoth Pool
122,000 AF
Edison Lake
125,000 AF
Crane Valley
45,500 AF
Huntington Lake
89,000 AF
Florence Lake
64,000 AF
Kerckhoff Reservoir
4,188 AF
Shaver Lake
136,000 AF
Redinger Lake
26,000 AF
Millerton Lake
520,500 AF

Storage	Capacity (AF)
Total Upstream	611,688
Millerton Lake	520,500
Total	1,132,188

Figure 3: The Big Creek system, with the capacities indicated in acre-feet (AF). Figure credit: [5].

The map on the right shows the same system, except it is overlayed with the capacities of the various reservoirs; note that it also includes two reservoirs owned by Pacific Gas and Electric (Crane Valley Reservoir and Kerckhoff Reservoir) as well as a Central Valley Authority reservoir (Millerton Lake).

Engineering Background and History

At the start of the 20th century, Henry Huntington decided to create the Big Creek Hydroelectric Project in order to power Los Angeles. Development of the Big Creek system started with the construction of a railroad (called the “Slow, Jerky, and Expensive”) for transportation to Big Creek. In 1912–3, the dams for the Huntington Lake reservoir were constructed and connected to Powerhouse 1 by a 4000-foot ($\sim$0.8 mile) tunnel with a 6-foot radius. Powerhouse 2 and a 4-mile tunnel to the reservoir were then created, as well as 243 miles of transmission lines, in order to channel the power to Los Angeles.

In the following decades, the other dams, tunnels, and powerhouses were added, with each powerhouse utilizing the same water flow but built at a different height. The system was completed in the 1980s with the construction of the Balsam Meadow Dam at Balsam Forebay in 1985, situated just northeast of Shaver Lake, and an accompanying powerhouse in 1986, constructed 1000 feet underground.

The most notable construction in the series was the creation of the multiple-arch Florence Lake Dam in 1920. This dam was impressive in how it was designed to use less concrete and how it was built 7200 feet above sea level upon granodiorite. With fifty-eight 50-foot arches and a total length of 3156 feet across, it was the longest multiple-arch dam in the world at the time of construction [9]. Additionally, a 13-mile hard-rock tunnel, dubbed the Ward Tunnel, was constructed to connect the powerhouses to Florence Lake [9].

It is thanks to the Big Creek system's incredible height differences that a great amount of power is produced from a relatively small amount of water. Even a single drop of water produces an astonishing amount of energy by dropping a total of 6200 feet (the height difference between the highest reservoir and the lowest powerhouse), and the Big Creek system's water has come to be known as the "Hardest Working Water in the World."

Figure 4: Pictured is a prominent granite dome above the site of Powerhouse 1, which was named after William G. Kerckhoff by the engineer who initially designed the Big Creek Hydroelectric Project, John Eastwood [7]. Kerckhoff owned half the stock in Huntington's Pacific Light & Power Company, and was its president.

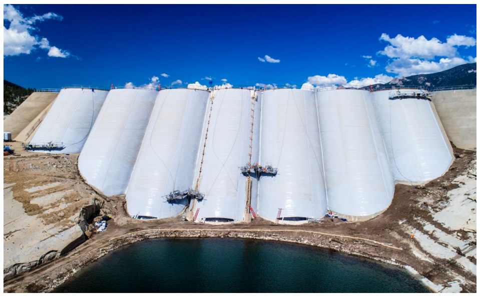


Figure 5: The multiple-arch structure of the Florence Lake dam is evident in this photograph. Note also that this image showcases the polyvinyl chloride (PVC) liner, which was added to the dam in 2014 in order to waterproof the concrete structure and reduce its freeze-thaw damage [4].

(Unless otherwise noted, I referenced [12] for this section.)

The Project's Relationship with the Environment

Hydroelectric power is not generally considered to be a clean energy source in California because of its many environmental impacts; most famously, major California dams have been associated with the decline of fish populations [8]. As might be expected, some environmental concerns have been raised for the Big Creek system as well: for example, the SCE has noted that the system could potentially impact mule deer with its spillage [2]. However, all the environmental concerns raised have been relatively minor [2].

Inversely, there have been concerns in recent years about the changing environment's impact on the Big Creek system and its ability to produce hydroelectric power. For example, one case study found that natural and anthropogenic aerosols could result in a reduction of runoff water entering the system; in particular, their simulation suggested there would be a 6% reduction in annual hydropower generation as a result [6]. Another study found that climate change projections mostly resulted in reduced runoffs, some of which could potentially require changes to the reservoir system [10].

Conclusion / Future of the Project

The Big Creek Hydroelectric Project has been around for over a hundred years, and it has a special place in the history of California and Los Angeles. Far from being a relic of the past, however, it continues to operate and change; one 2018 study even proposed that the dams could be retrofitted with a pumped storage system to store a vast amount of solar and wind energy [1]. During our visit, Dam 1 at Huntington Lake will be undergoing infrastructure improvements (the construction started at the beginning of May and is projected to end in November) [3].

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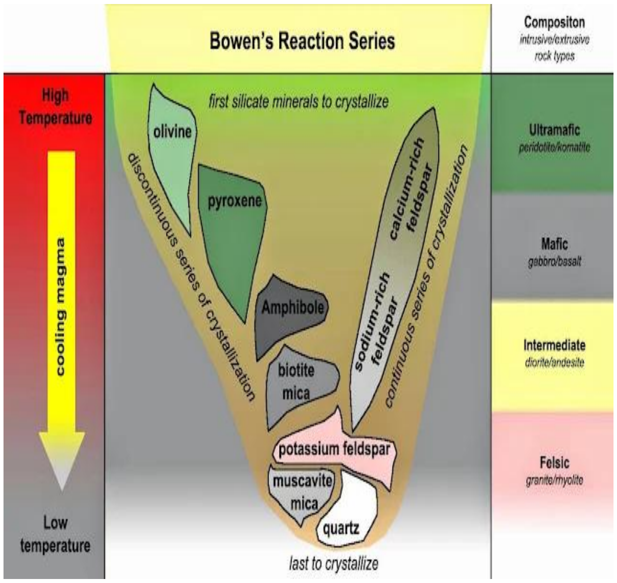
(8) Granite Crystallization, Types (S, I, A) and Protoliths — *Amanda Bednarick*

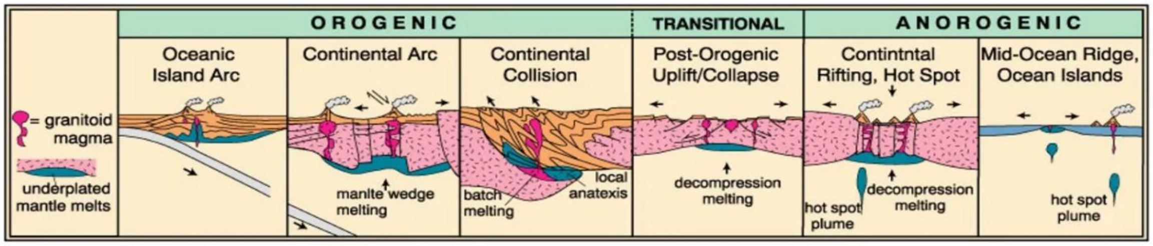
Types of granite

By Dr. Amanda Bednarick, PhD


Bowen's Reaction Series
Compositon
intrusive/extrusive rock types
High Temperature
cooling magma
Low temperature
first silicate minerals to crystallize
olivine
pyroxene
Amphibole
biotite mica
potassium feldspar
muscavite mica
quartz
last to crystallize
discontinuous series of crystallization
calcium-rich feldspar
sodium-rich feldspar
continuous series of crystallization
Ultramafic
peridotite/komatiite
Mafic
gabbro/basalt
Intermediate
diorite/andesite
Felsic
granite/rhyolite

Granites are igneous rocks with high SiO_2 content. Its primary minerals are quartz, feldspar, and mica.

Granite represents the final stages of Bowen's reaction series, meaning it crystallizes at low temperatures and pressures. This explains why granite is so thermodynamically stable at the Earth's surface (compared to, e.g., basalt).


OROGENIC
TRANSITIONAL
ANOROGENIC
= granitoid magma
underplated mantle melts
Oceanic Island Arc
Continental Arc
Continental Collision
Post-Orogenic Uplift/Collapse
Contintntal Rifting, Hot Spot
Mid-Ocean Ridge, Ocean Islands
manlte wedge melting
batch melting
local anatexis
decompression melting
hot spot plume
decompression melting
hot spot plume

Different tectonic settings spawn different granite types.

i-type granites form at convergent margins. The "I" stands for igneous because the protolith is a subducting slab of oceanic crust (igneous basalt).

s-type granites form when sediments ("s") get buried to the point that they melt and form a new rock. They contain muscovite mica, owing to the excess alumina contributed by clays (in the sediment protolith) that cannot be accommodated by crystallizing feldspar.

A-type granites are dry (anhydrous) and they form in within-plate settings (anorogenic). Most alkaline granites are a-type. The term is kind of a catch-all, but one unifying feature of a-type granites is they are enriched in Fe relative to Mg.

MANDATORY QUIZ

WHICH GRANITE TYPE ARE YOU?

i-type

-kinda confrontational

-you live in California

s-type

-sparkly

-you get overwhelmed by all the alumina but feel like you have to accommodate everyone.

a-type

-enigmatic

-you love iron more than the others

-misunderstood…

PERFECT Attendance

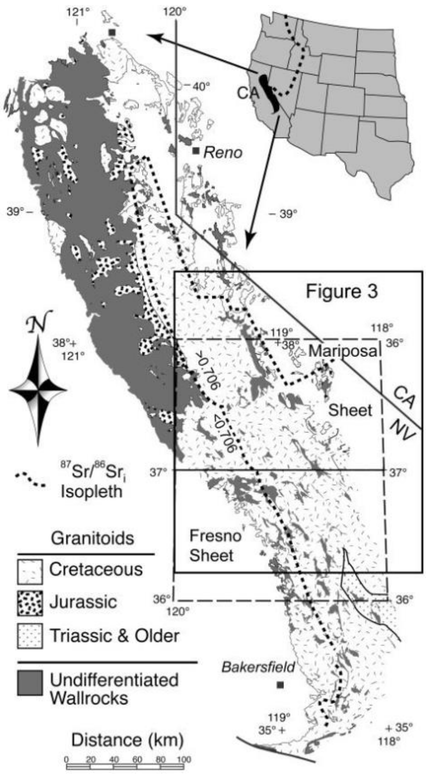
5 years of Ge 136

2021-2022
2022-2023
2023-2024
2024-2025
2025-2026
fall
winter
spring
GOD NEVER FAILS
SALVATION MOUNTAIN

The Magmatic History of the Sierra Nevada Batholith

26 SP GE136c
Sophia Ji-In Ree

Figure 1. Generalized Geological map of the Sierra Nevada Batholith (Lackey et al., 2008)


121°
120°
40°
CA
Reno
39°
39°
Figure 3
38°
121°
119°
38°
118°
36°
Mariposal
Sheet
CA
NV
>0.706
≤0.706
$^{87}Sr/^{86}Sr_i$ Isopleth
37°
37°
Granitoids
Cretaceous
Jurassic
Triassic & Older
Undifferentiated Wallrocks
Fresno Sheet
36°
120°
36°
Bakersfield
119°
35°
35°
118°
Distance (km)
0 20 40 60 80 100

What is a Batholith: Intrusion vs. Pluton vs. Batholith

There are many words for intrusive rocks (rocks that formed by cooling of magma underground). An ***intrusion*** is the broadest term. It is any *body of magma that cools underground*. Its size varies from few meters to hundreds of km. It is formed by magma injection into country rock. On the contrary, a ***pluton*** is *a distinct, singular intrusive magma body*. A pluton normally ranges few to tens of km across, and is formed by one distinct, localized magma event. Lastly, the subject of our interest: a ***batholith*** is *a massive, composite crustal intrusion*. It is greater than 100 km^2 in exposed area, and forms by the coalescence of many individual plutons over time.

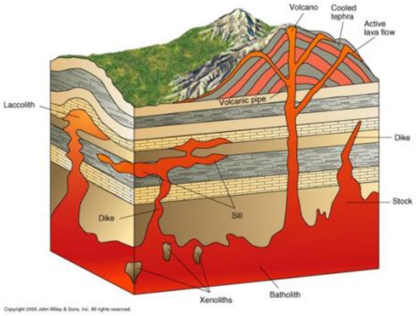

Volcano
Cooled tephra
Active lava flow
Laccolith
Volcanic pipe
Dike
Stock
Dike
Sill
Xenoliths
Batholith
Copyright 2005 John Wiley & Sons, Inc. All rights reserved.

Figure 2. Types of intrusive (plutonic) rocks (Skinner, 2004)

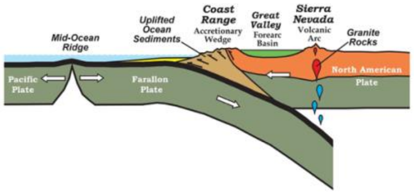

Mid-Ocean Ridge
Uplifted Ocean Sediments
Coast Range Accretionary Wedge
Great Valley Forearc Basin
Sierra Nevada Volcanic Arc
Granite Rocks
Pacific Plate
Farallon Plate
North American Plate

Figure 3. Types of intrusive (plutonic) rocks (Lillie, 2005)

Geological Background

The Sierra Nevada Batholith (SNB) is a massive Mesozoic continental arc batholith extending for more than 600 km along eastern California (Bateman and Eaton, 1967; Bateman, 1992). It forms the crystalline core of the Sierra Nevada Mountain range and represents one of the best exposed continental magmatic arc systems in the world.

The batholith was constructed along the western margin of North America during eastward subduction of the Farallon Plate beneath the continent (Hamilton, 1969; Saleeby, 1990). It consists predominantly of granitic plutons. These plutons intruded Paleozoic to Mesozoic sedimentary, volcanic, and metamorphic rocks during prolonged arc magmatism from the Triassic to Late Cretaceous.

The Sierra Nevada Batholith is traditionally divided into western and eastern belts based on lithology, age, deformation style, and crustal level of exposure (Kistler, 1990; Bateman, 1992). The western belt generally contains older, more mafic, and more deformed plutons associated with oceanic arc terranes, whereas the eastern belt is dominated by younger, larger, and more felsic plutons emplaced into continental crust.

Geologically, the batholith forms part of the broader Cordilleran magmatic arc system that extended from present-day Canada to South America during the Mesozoic. Together with the Peninsular Ranges Batholith and related arc systems, the Sierra Nevada Batholith records the long-term growth and differentiation of continental crust along an active convergent margin.

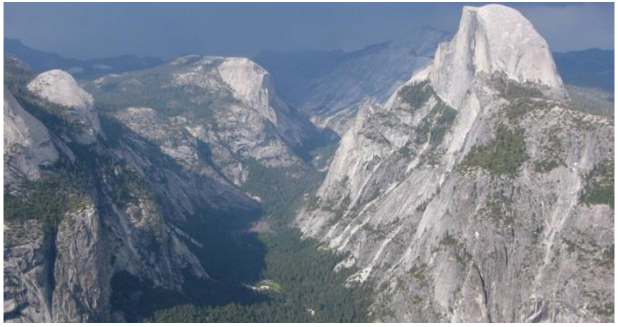


Figure 3. Photo of the Yosemite Valley and Half Dome Complex, Yosemite National Park (UNESCO)

Timing of Magmatism

Magmatism in the Sierra Nevada Batholith occurred episodically from the Triassic through the Late Cretaceous, although most plutonism took place during the Jurassic and Cretaceous (Bateman, 1992).

Early plutonic activity (ca. 220–170 Ma) consisted mainly of mafic to intermediate plutons representing the initial establishment of subduction-related magmatism. During the Jurassic (ca. 170–145 Ma), magmatism intensified during the Nevadan Orogeny, accompanied by terrane accretion, deformation, and regional metamorphism (Saleeby, 1990). The most significant phase occurred during the Cretaceous flare-up event (ca. 125–80 Ma), when magma production rates dramatically increased and much of the present-day batholith was emplaced (Ducea, 2001). Large plutonic complexes such as the Tuolumne Intrusive Suite formed during this interval. U–Pb zircon geochronology indicates that pluton emplacement migrated eastward with time (Coleman et al., 2004). After approximately 80 Ma, magmatic activity waned, and the batholith underwent cooling, uplift, and erosion.

Petrogenesis

The Sierra Nevada Batholith represents a classic calc-alkaline continental arc generated through long-lived subduction-related magmatism.

Primary magmas were produced within the mantle wedge above the subducting Farallon Plate (Hamilton, 1969; Ducea, 2001). These hydrous basaltic magmas evolved through fractional crystallization, magma mixing, and crustal assimilation during ascent and storage within the crust. Western Sierra plutons are generally more mafic and isotopically primitive, indicating stronger mantle contributions (Kistler, 1990). In contrast, eastern Sierra granitoids display more evolved isotopic signatures, suggesting greater crustal involvement. Many granitoids are interpreted as hybrid magmas formed through repeated intrusion of mantle-derived basalt into the lower crust, causing partial melting and magma mixing (DePaolo, 1981; Ducea, 2001).

One of the best studied plutonic complexes is the Tuolumne Intrusive Suite in Yosemite National Park (Coleman et al., 2004; Glazner et al., 2004). Field relationships and geochronology indicate that the suite was assembled incrementally over several million years through repeated magma injections rather than crystallizing from a single large magma chamber.

Tectonic Significance

The Sierra Nevada Batholith is one of the most important continental arc systems on Earth and provides key insights into continental crust generation, subduction-related magmatism, magma differentiation, and batholith construction. Because the batholith preserves a relatively continuous cross section through an ancient continental arc, it has become a major natural laboratory for studying magma evolution, crust–mantle interaction, and incremental pluton assembly.

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Bateman and Eaton, 1967; Sierra Nevada batholith

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Ducea, 2001; The California Arc: thick granitic batholiths, eclogitic residues, lithospheric-scale thrusting, and magmatic flare-ups

Glazner et al., 2004; Are plutons assembled over millions of years by amalgamation from small magma chambers?

Hamilton, 1969; Mesozoic California and the underflow of Pacific mantle

Kistler, 1990; Two different lithosphere types in the Sierra Nevada, California

Lackey et al., Dynamic Magma Systems, Crustal Recycling, and Alteration in the Central Sierra Nevada Batholith: the Oxygen Isotope Record, *Journal of Petrology*, Volume 49, Issue 7, July 2008, Pages 1397–1426

Robert J. Lillie, 2005, “The Geology of our National Parks, Monuments and Seashores,” W. W. Norton and Company, 298 pp.

Saleeby, 1990; Progress in tectonic and petrogenetic studies in an exposed cross section of young (~100 Ma) continental crust, southern Sierra Nevada, California

Tobisch, Fiske, and Saleeby, 1995; Steep tilting and extensional collapse of the Sierra Nevada Batholith

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Geochemistry of Hot Springs in the Sierra Nevada Area

Zhehao (Garry) Zhang, Ge 136c

Introduction:

The Geochemistry of hot springs is integral to understanding the hot springs themselves, as the chemical composition of the spring water (and gas) is heavily influenced by the temperature of the hydrothermal system, composition of the interacting rocks, and the source of the water.[1] This not only informs us of the geology of the area, but also could potentially tell us about available geothermal resources that could be utilized, like the Coso geothermal field since 1987.[2]

Geologic background:

The Sierra Nevada area, despite the batholith being formed between 105 and 85 Ma and now uplifted and the top eroded away, still has active volcanism (e.g. Red Cones, southwest of Mammoth Mountain, unglaciated, and dated to 8ka ago), which is what heats up and powers the hydrothermal systems that produces the hot springs today.[3] The hot springs nowadays issue from faults within the volcanic rocks, and are likely heated from magmatic intrusions underneath the Sierra Navadas like the nearby Long Valley Caldera system.[4]

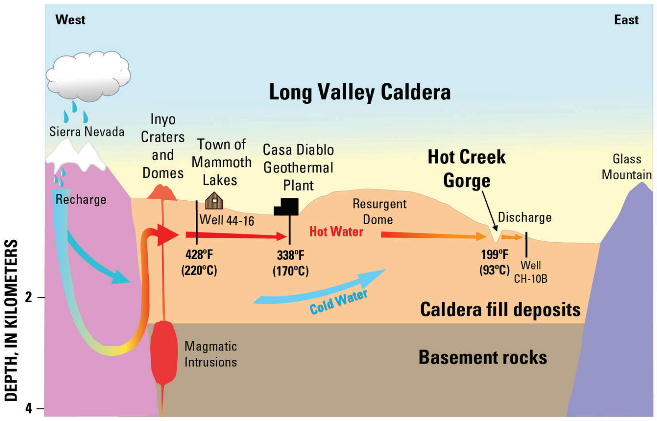
West
East
Long Valley Caldera
Sierra Nevada
Inyo Craters and Domes
Town of Mammoth Lakes
Casa Diablo Geothermal Plant
Hot Creek Gorge
Glass Mountain
Recharge
Well 44-16
Resurgent Dome
Hot Water
Discharge
428°F (220°C)
338°F (170°C)
199°F (93°C)
Well CH-10B
Cold Water
Caldera fill deposits
Magmatic Intrusions
Basement rocks
DEPTH, IN KILOMETERS
2
4

Fig. 1 Long Valley Caldera Hydrothermal System.[4]

Mono Hot Springs:

Unfortunately, the only available datum for Mono Hot Springs comes from Mariner et al.[5] These hot springs spring from granitic rocks, but the heat sources can come from surrounding young basalt flows. The dissolved ions are majority Na^+/Cl^- with moderate amounts of Ca^{2+}, SiO_2, and SO_4^{2-}, and the solution has a pH of 6.92, with the contributors to alkalinity being carbonates (not measured in solution, but inferred from CO_2 in the gas composition) and silicates. It is slightly saline at 1200 mg/L. Na/K and Na/K/Ca geothermometers give measured aquifer temperatures of 321C.[6] The Na/K/Ca geothermometer from the same source gave a temperature of 38.5C, which discrepancy could be resulted by mixing of heated water with the regional general groundwater discharge.

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$$T°C = \frac{1217}{\log(Na/K) - 1.483} - 273.15$$

Fig. 2 Na/K geothermometer used [6], Na/K/Ca geothermometer from the same reference

The isotopic composition is similar to that of fresh water in the region (-16.05 $\delta^{18}O$), also indicating source of water from rain or other precipitation, and could still support regional groundwater mixing which could explain the geochemical thermometer discrepancy. It is significantly lower than that of e.g. mono lake (-1.4) which presumably is slightly enriched in ^{18}O from evaporation.

The gas composition is 95% N_2, 2.7% CO_2, 1.7% O_2+Ar and trace (0.1%) methane and ethane. The majority N_2 discharge indicates the spring comes from a low-temperature hydrothermal system (high-temperature systems discharge CO_2 ultimately sourced from magma), which indicates that it definitely is lower than the geochemical thermometer of 321C. Mariner et al. gives a temperature based on the silica geochemical thermometer to be 110C.

Miracle(Hobo) Hot Springs/Remington Hot Springs:

Again, the only datum for this system was for Miracle Hot Springs by a USGS report.[7] It has a pH of 9.25, TDS of 234 mg/L (quite low salinity), Na, K, Ca at 71, 1.0, 1.5 mg/L, and Cl^- at 41 and SiO_2 at 50 mg/L, providing most of the alkalinity again apart from dissolved CO_2. There is no gaseous data for this spring. The Na/K and Na/K/Ca geochemical thermometers give 164C and (8C ?!, there is definitely something off here in the ion compositions), and the Na/K data seems reasonable.

Note on Geochemical thermometers:[8]

The geochemical thermometers use the temperature-dependent ion exchange of the hot aquifer with surrounding rocks, or solubility of minerals such as quartz, chalcedony, cristobalite, or amorphous silica (Si geothermometers is most common here). This source gives a different Na/K/Ca geothermometer here, as well as a few others which might not apply (such as ^{18}O, due to no good data on isotope ratios in HSO_4^-, which is used as a reference that doesn't really exchange with the oxygen in the minerals.

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(11) John Muir and the Preservation of the Sierra Nevada — *Debarun Mukherjee*

John Muir and the Preservation of the Sierra Nevadas

Debarun Mukherjee

Ge136c-2026

The Sierra Nevada is not just a scenic mountain range; it is an exposed archive of continental arc magmatism, tectonic tilting, river incision, and Quaternary glaciation. The range is dominated by granitic rocks of the Sierra Nevada batholith, emplaced during Mesozoic subduction along western North America and later exhumed by uplift and erosion [3]. Its modern topography reflects both long-term tectonic forcing and surface processes: rivers cut into the rising range, then Pleistocene glaciers widened, polished, and overdeepened many valleys [4,5]. John Muir's historical importance is that he translated these geomorphic observations into a public argument for preservation.

Muir recognized that many Sierra landscapes could not be explained by ordinary stream erosion alone. In the Mountains of California and The Yosemite, he repeatedly described polished granite pavements, moraines, erratic boulders, cirques, and glacier-fed lake basins as evidence for former ice flow [1,2]. He noted that when ice had moved through the canyons, it should have left directional scratches, smoothed bedrock, overdeepened basins, and sediment ridges at former ice margins, observations that were then confirmed.

Modern geomorphology gives Muir's observations a process-based explanation. Basal debris in moving ice abrades granite into smooth pavements and striations, while plucking removes joint-bounded blocks and steepens valley walls. Because granitic plutons are cut by fracture networks, glacial quarrying can efficiently produce the cliff-dominated topography seen in Yosemite, Kings Canyon, and adjacent high-country basins [3,5]. Later research refined the timing of this story: the Sierra experienced repeated Quaternary glaciations, including major advances such as Sherwin, Tahoe, Tioga, and Recess Peak [5].

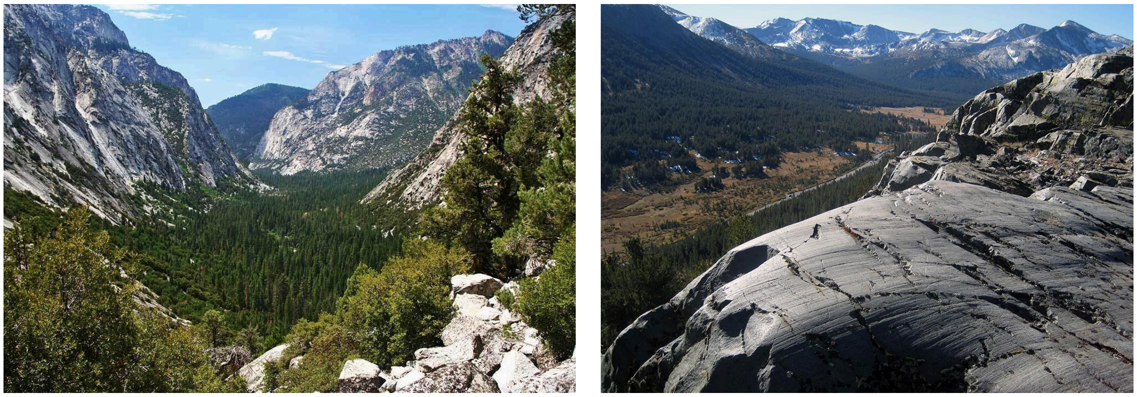

Figure 1: Geomorphological evidence for alpine glaciation in Kings Canyon in the Sierra Nevada, including U-shaped valleys, glacial striations, and polished granitic bedrock.

That the same argument can be tested with simple observations. A polished granite surface with scratches can record former ice-flow direction; a ridge of unsorted sediment can mark an ice margin; a cirque or tarn can indicate headward glacial erosion; and a hanging valley can show that a tributary glacier eroded less deeply than the trunk glacier. The fun historical twist is that Muir's geology became political. In the late nineteenth century, western landscapes were often valued mainly for timber, grazing, mining, and water supply. Muir argued instead that the Sierra should be protected because it preserved evidence of long-term Earth processes. That argument helped build support for national parks and for the Sierra Club, founded in 1892 [6,7]. His writing connected careful observation to public action: geology became part of the case for conservation.

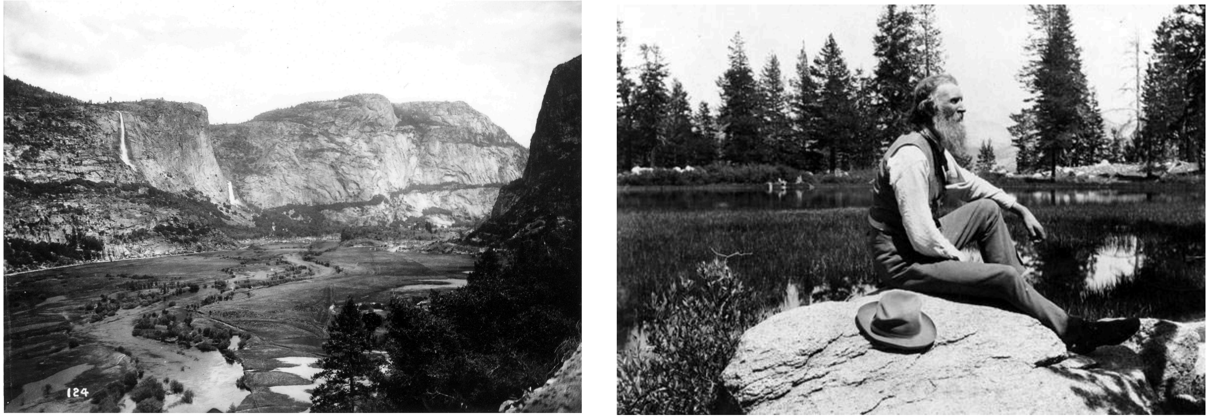

Figure 2: Historic representation of Hetch-Hetchy, prior to inundation and picture of John Muir in Kings Canyon.

Hetch Hetchy: where glacial geology met politics

Hetch Hetchy is the best case study because it links science with politics and history. Muir described the Tuolumne River valley as a counterpart to Yosemite, formed in the same gray granite and by the same glacial processes (Figure 2) [2]. In modern terms, the valley was a glacial trough: pre-existing fluvial topography was modified by ice through abrasion, quarrying, and sediment transport. Muir's language was often poetic, but his evidence was geological - valley form, polished rock, waterfalls, and the spatial relationship between granite walls and meadow floor.

The controversy came when San Francisco sought to dam Hetch Hetchy for municipal water. Muir and other preservationists argued that flooding the valley would destroy a scientifically and aesthetically rare landscape; supporters of the dam argued for public utility and water security. The O'Shaughnessy Dam was ultimately completed in 1923, inundating the valley, but the debate became one of the defining moments in American conservation history [6,7].

Muir's legacy was not only that he loved mountains, but that he made glacial geology culturally powerful. The features visible in the Sierra today - granite cliffs, polished bedrock, moraines, cirques, alpine lakes, and U-shaped valleys - record linked tectonic, magmatic, fluvial, and glacial processes. Muir turned those features into a story the public could care about, helping preserve landscapes where we can still test the science directly in the field.

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The John Muir Trail: Background and Details

By Yi Lin

Who is John Muir?

John Muir (pronounced 'meer') was born in Dunbar, Scotland in 1838,where he resided for 11 years prior to emigrating to Wisconsin (National Park Service, 2024; *John Muir | Wisconsin Historical Society*, 2012). It was there that he self taught himself subjects like mathematics, botany, and geology while working on the family farm before working in machine shops around Indianapolis after dropping out of University of Wisconsin-Madison. In 1867, an accident at work blinded him temporarily, which became the turning point for him to step back from the world of industrialism. He then started to live as a wandering naturalist (*John Muir | Wisconsin Historical Society*, 2012), and began his famous thousand mile walk to Florida, then Cuba and Panama - eventually he arrived in San Francisco in early 1868 (*John Muir | Wisconsin Historical Society*, 2012).

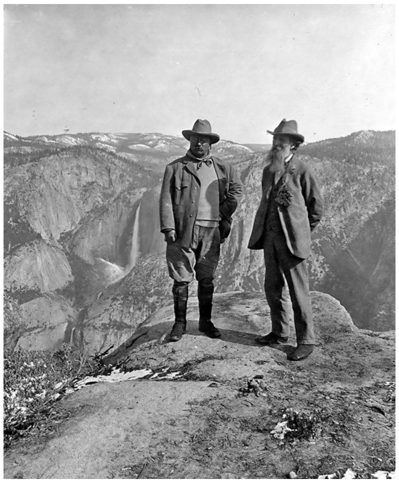
1872/1873, photograph of young John Muir. Source: johnmuir.org/pictures/

1889, grazing sheep at Yosemite Valley Meadows. source: NPS "Yosemite Nature Notes: Bighorn Sheep"

From there, he traveled inland and ultimately ended up at around Yosemite and the high Sierras as a sheepherder. It provided the background for *The Yosemite,* a book he wrote detailing the landscape, fauna and forces that've shaped the valley. In particular, he argued that societies required "beauty as well as bread," in response to the destruction of the valley by herds of sheep grazing, so damaging that he referred to the herds as "hoofed locusts" (Wood, 2026).

Roosevelt & The Sierra Club

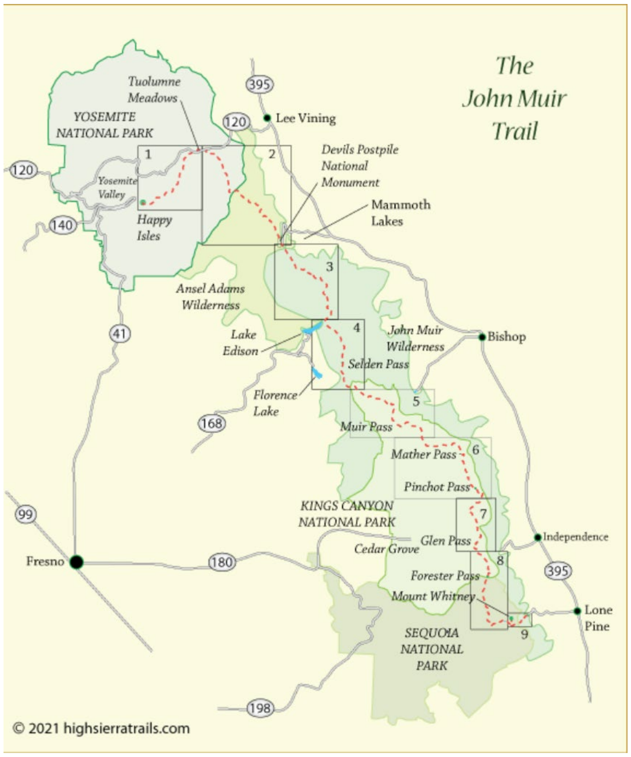
The Yosemite Grant Act of 1864 passed by Abraham Lincoln had reserved Yosemite valley for public recreation (California State Parks, 2014), but as the first act of its kind its protections were limited, and the land remained vulnerable to grazing, timer extraction, and commercial development. Muir wrote 300 magazine articles and 11 other books that helped build support for better conservation efforts, eventually catching the eye of then President Theodore Roosevelt. A subsequent camping trip between the two in Yosemite led to Roosevelt helping to officially establish Yosemite National Park in 1890. Just 2 years later, Muir founded the Sierra Club, which still remains to this day as one of the most influential environmental organizations in the US. Another bill in 1906 helped return Yosemite Valley and Mariposa Grove under federal management as part of the park, and the additional protected land helped the Sierra Club secure funding in 1915 for the construction of the John Muir Trail (JMT), eventually finishing in 1938.



1903. Muir with Roosevelt on Glacier Pt in Yosemite. NPS

How to Hike the JMT

The JMT is a legendary ~214 mile long trail stretching from Yosemite Valley to Mt. Whitney in California. Most of the trail itself is above 8,000 feet in elevation, proving itself to be a challenge to the approximate 1500 hikers that attempt to hike it in full each year. One of the most challenging things to do with regards to JMT is actually being able to secure a permit for the hike itself. Only about 30% of applications are accepted, with factors like a smaller group size and scheduling flexibility playing a decent sized role in approval. There are Southbound Permits (Yosemite start), Northbound Permits (via Whitney Portal or with Inyo National Forest, Horseshoe Meadow, Cottonwood Pass, or Cottonwood Lakes). Typical times to do this are from June through August, with temperatures typically ranging from ~25 degrees Fahrenheit to upper 80s, with possible rain and hail. On average, hikers take about 3 weeks, but fast hikers can complete in about 10 days (Hopfensperger, 2021).


The John Muir Trail
Tuolumne Meadows
YOSEMITE NATIONAL PARK
Yosemite Valley
Happy Isles
395
120
140
41
168
99
180
198
Lee Vining
Devils Postpile National Monument
Mammoth Lakes
Ansel Adams Wilderness
Lake Edison
Florence Lake
John Muir Wilderness
Selden Pass
Bishop
Muir Pass
Mather Pass
Pinchot Pass
KINGS CANYON NATIONAL PARK
Glen Pass
Cedar Grove
Independence
Fresno
Forester Pass
Mount Whitney
Lone Pine
SEQUOIA NATIONAL PARK
1
2
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Suggested Items	What to Eat
• Ultralight shelter, sleeping bag (15-20 degrees) + pad (high R value), and backpack (~55-65 L) • Avoid cotton, merino wool recommended • Breathable, insulating, waterproof layers • Cooking system and fuel (sleep with fuel in case too cold) • Bear canister (takes up like 90% of bag) • Water filtration system • Hiking shoes a size or so up to accommodate for swelling	• Dehydrated Quinoa Porridge • Freeze Dried Yogurt Melts • Powdered Eggs • Instant Oatmeal • Cowboy Caviar • Pasta Salad • Chicken/tuna/spam packets • Variety of energy bars • Jerky, candy, trail mix

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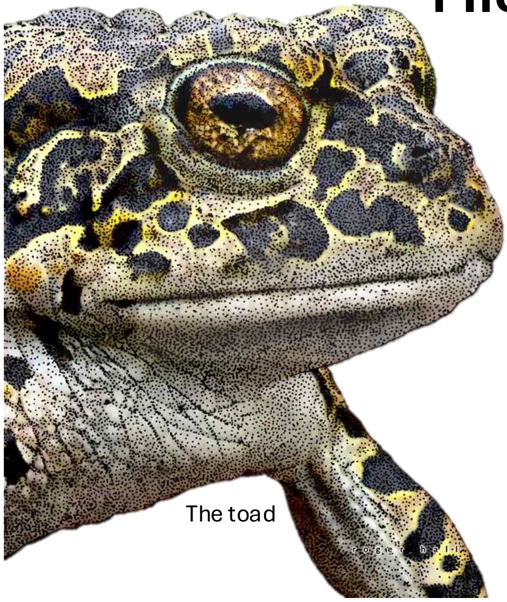
(13) Yosemite Toad: Role of Skin Bacteria in Bd Fungus Survival — *Richard Horak*

Microbial Friends and Foes of the Yosemite Toad

By Dr. Richard Horak Ph.D.

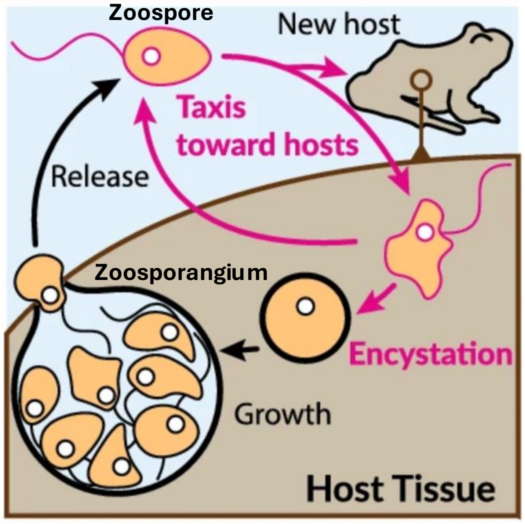


Who is the Yosemite toad?

The Yosemite toad (*Anaxyrus Canorus*) belongs to the frog Family Bufonidae and is therefore, a TRUE toad. This toad is endemic to the Sierra Nevada found in subalpine regions between 6000 to 11000 ft elevation. After a long hibernation, the toad migrates to breeding pools in the late spring, "tiptoeing" across snowbanks while eating anything that will fit inside their mouth. However, this beloved species is threatened.

Microbial foe: *Batrachochytrium dendrobatidis*

The Yosemite toad faces challenges from drought and habitat loss. However, like many amphibians, their main predator is *Batrachochytrium dendrobatidis,* also known as *Bd* or the amphibian chytrid fungus. Thought to originate from Africa or Asia, this fungus has spread across the globe. *Bd* is debated be the cause of the greatest loss of biodiversity attributable to one disease, affecting over 30% of amphibian species across the globe and linked to the extinction of over 100 species in the last 50 years.



The lifecycle of *B. dendrobatidis*

Chytrid fungi such as *Bd* are "zoosporic" meaning they form single cell motile "zoospores" to swim through aqueous environments. These zoospores can recognize nutrients from the toad's skin and swim towards this new host. Once there, they either invade the skin or attach to its surface before undergoing "encystation", forming a cell wall and becoming a "zoosporangium". The zoosporangium forms a network of hyphae which can degrade nutrients from the frog to fuel the production of more zoospores. Finally, the zoosporangium opens, releasing new zoospores into the environment or the frog host. This infection leads to disruption of ion homeostasis, osmoregulation, hydration, skin sloughing, and eventually cardiac arrest – chytridiomycosis.

The mystery of toad deaths

In the 1980s it became clear that amphibians were dying at increasing rates. By 1999 the scientists Lee Berger (shout out Australia) and Joyce Longcore discovered that *Bd* fungus was the primary cause. Two different groups led by Vance Vredenburg and Reid Harris worked to track the populations of frogs and salamanders respectively. Both noticed a mystery. Across multiple amphibian communities, including the Yosemite toad, populations were experiencing dramatically different mortality rates despite similar exposure to *Bd* fungus.

Colonies of *J. lividum* producing violacein

Microbial friend: *Janithobacterium lividum*

By swabbing and culturing microbes from the skin of these amphibians, Reid Harris showed that red-backed salamanders colonized by the skin bacterium *Janithobacterium lividum* survived *Bd* fungus at far higher rates than those that lacked this bacterium. Throughout the 2000s Vredenburg and Harris expanded this work, showing this to be true in other frog and amphibian species, including the Yosemite toad. Within controlled laboratory conditions, all frogs given *Bd* fungus alone died while all frogs given both *Bd* and *J. lividum* lived.

Dyes the help you not die: Violacein production by *J. lividum*

J. lividum is a gram-negative aerobic soil bacterium known for its production of violacein which gives it a dark violet-black color. Violacein has a relatively high K_{OW} of 3.42 meaning it easily integrates into cell membranes. Red-backed salamanders colonized by *J. lividum* violacein concentrations were found exceeding 200 uM yet even just 1.82 uM completely inhibits growth of *Bd*. This molecule can engage in redox-chemistry being a potent antioxidant. It can kill a variety of gram-negative bacteria, such as *Staphylococcus aureus* as well as fungi, believed to disrupt lipid membranes as part of its lethality. Current efforts are underway to deliver *J. lividum* to these species and better characterize the skin microbiology of amphibians.

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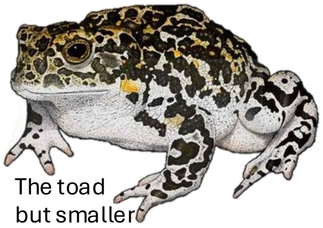
The toad but smaller

(14) Fire Ecology of the Western Sierra & Effects of Suppression and Climate Change — *Jarek Kwiecinski*

Jarek Kwiecinski
Ge136c

Fire has shaped the forests of the western Sierra for millenia. Charcoal deposits and pollen cores both suggest periods of varied fire intensity throughout the Holocene that altered the structure of forest plant communities. Significant fires occurred at the end of last ice age as tree species migrated upwards in elevation, leading to the expansion of mixed conifer forests that now dominant the lower elevations in the Sierra. The frequency and intensity of fire varied dramatically across this very heterogeneous landscape. In sequoia groves, fires occurred at least every 30 years prior to Euro-American settlement. More broadly, between one quarter and one third of the Sierra's forests had a low tree density described as being "open" and "park-like," according to early American surveying efforts and photographs from the late 19th century. This forest structure was maintained by frequent, low-severity fires, inspiring current management practices that attempt to prevent future fires by removing fuels (Skinner and Chang, 1996).

This paradigm, that low intensity fires dominated the historical fire regime, is not universally accepted. Broader, regional scale surveys of historical records suggest that much of the Sierra supported dense forests dominated by small young trees. These trees would have grown in burned patches left behind by high severity fires that returned roughly every 500 years. Such rare but impactful events gave rise to a heterogenous forest structure, with some areas featuring open old growth trees and others existing in an earlier stage of succession (Odion et al., 2014). This diversity of habitats is needed to support wildlife with different life strategies, including some Sierra bird species that preferentially inhabit high severity burn scars (Hutto, 2008). The park-like forests famously documented by John Muir may represent a biased sample of the large variability in Sierran forest ecosystems. Further, the low intensity fires that also occurred in these ecosystems were not able to completely eliminate high severity fire over multi-century time scales (Odion et al., 2014).

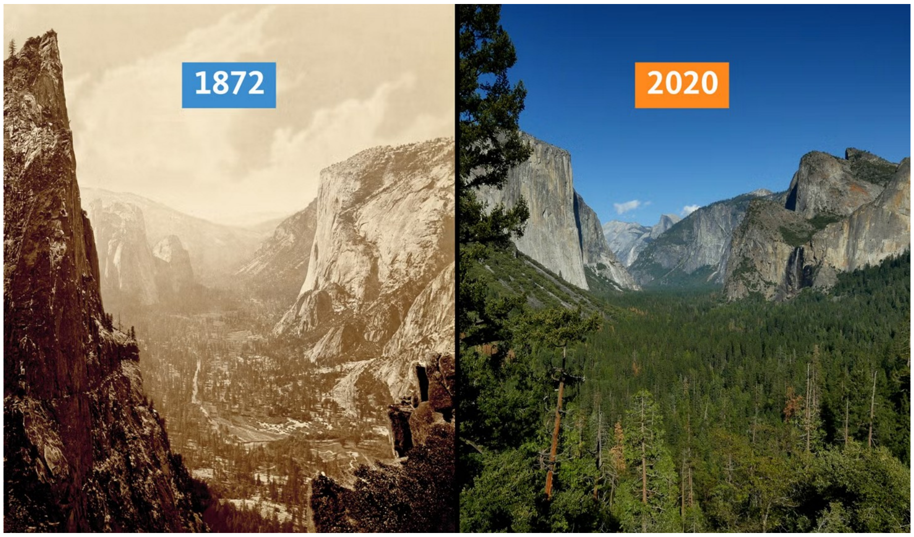

Figure 1: Increase in tree coverage in Yosemite Valley following Euro-American settlement (University of California, 2022).

Indigenous peoples contributed to this historical fire regime. Fires were used to promote the growth of plants useful for weaving, to encourage acorn production, and to protect valuable old oak trees from high severity fires (Skinner and Chang, 1996). Burning also promoted the establishment of oak trees over pines, as many California oaks are able to quickly resprout after fire. Finally, burning decreased the amount of water removed by evapotranspiration, raising the water table and making remaining trees more resistant to drought (University of California, 2022). The rapid decline in the indigenous population following Spanish settlement was associated with a large increase in area burned across the western Sierra, perhaps because the cultural burns that limited the potential for high severity fire did not continue (Taylor et al., 2016).

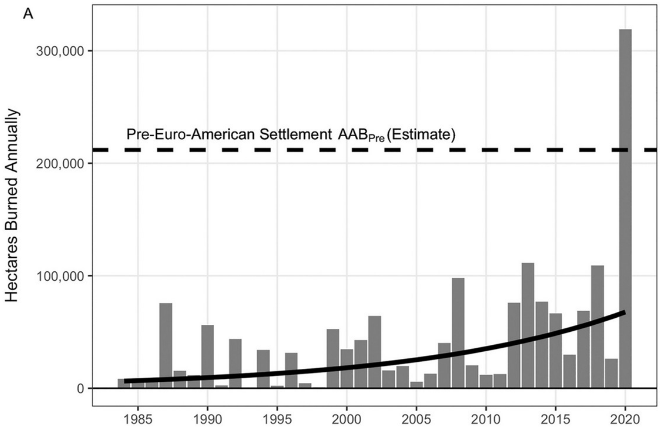

Figure 2: Fire supression can longer eliminate fires in the western Sierra, and the area burned even exceeded the pre-settlement average in 2020.

Regardless of the exact historical nature of Sierran forests, it is clear that Euro-American settlement and the concurrent beginning of fire suppression in the early 20th century led to a sharp decrease in the areal extent of wildfires. This has led to a fire deficit unprecedented in at least the last 1500 years. Climate change and increasing fuel loads have limited the efficacy of fire supression in recent years (Williams et al., 2023). Many large, high severity fires have occurred across the American West in recent decades, including the 2020 Camp Fire which burned the area surrounding Mono Hot Springs. 41% of this fire's nearly 600 square mile footprint burned at high severity, especially in areas where drought and bark beetles had caused extensive tree mortality from 2012 to 2016. This event was well outside the historical norm for this forest, likely exacerbated by fire suppression that increased tree density, driving competition for limited resources and increased bark beetle spread (Stephens et al., 2022). More generally, the annual area burned by wildfires in the western Sierra is approaching what was typically observed prior to Euro-American settlement. At the same time, the fraction of the area burned at high severity now exceeds the pre-settlement average, with the greatest change observed in low elevation mixed conifer forests like those we have visited on this trip (Williams et al., 2023). Finally, climate change has continued to increase the potential for severe wildfires by lengthening the fire season and worsening tree mortality (Cassell et al., 2019). Given these factors, the future of western Sierra forests is uncertain.

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Snow Surveys for LADWP

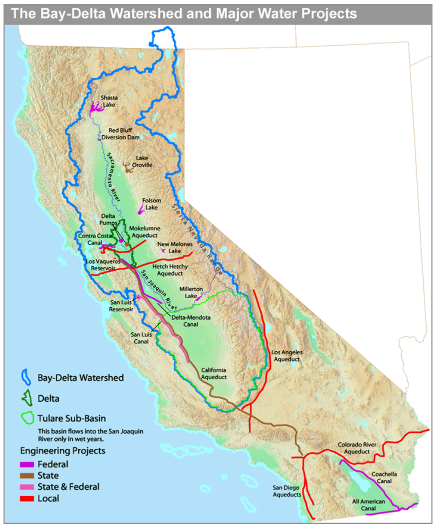
Konnor von Emster

Southern California Water Suppliers

As Angelinos (native or adopted), our survival depends on the ability of the Los Angeles Department of Water and Power (LADWP), Pasadena Water & Power (PWP), and the Metropolitan Water District (MWD) to provide us with fresh, clean, reliable drinking water.

These supplies come from three main sources depending on where one lives. Los Angeles receives about 48% from the LA Aqueduct, 41% from MWD, and 11% from groundwater and recycling[1] whereas Pasadena receives 60% of its water from MWD and the remaining as groundwater from the Raymond Basin[2]. MWD receives about 50% from local water supplies, 30% from the State Water Project (SWP), and 20% from the Colorado river[3]. An overview of the SWP, MWD, and LADWP is provided in the map to the right[4].

Among these sources, the LA Aqueduct and the SWP rely heavily on precipitation in the Sierra Nevadas. Forecasts of water availability must be made to maintain supply and price stability. Every winter, an estimated 1 to 10 trillion gallons of water settle into the Sierras as snow fall which replenishes many of the rivers, lakes, and aquifers that supply the SWP and LA Aqueduct[5]. To anticipate the available supply, the LADWP works with the California Department of Water Resources (DWR) on the California Cooperative Snow Survey Program (CCSSP) to measure snow pack using various instrumentation including manual surveys, remote sensing, and automated stations[6].


The Bay-Delta Watershed and Major Water Projects
Shasta Lake
Red Bluff Diversion Dam
Lake Oroville
Sacramento River
Folsom Lake
Sierra Nevada Range
Delta Pumps
Mokelumne Aqueduct
Contra Costa Canal
New Melones Lake
Los Vaqueros Reservoir
Hetch Hetchy Aqueduct
San Joaquin River
Millerton Lake
San Luis Reservoir
Delta-Mendota Canal
San Luis Canal
Los Angeles Aqueduct
California Aqueduct
Bay-Delta Watershed
Delta
Tulare Sub-Basin
This basin flows into the San Joaquin River only in wet years.
Engineering Projects
Federal
State
State & Federal
Local
Colorado River Aqueduct
Coachella Canal
San Diego Aqueducts
All American Canal

Snow Surveys

Snow surveying in the United States began on Mount Rose, Nevada, in 1906 when Dr. James E. Church Jr. developed practical methods for measuring both snow depth and water content[7]. These models were used to resolve the Tahoe Water War by showing that the water content of snow on Mt. Rose could predict the spring rise of Lake Tahoe. As the value of these surveys became clear, California established a coordinated statewide snow survey program in 1929.

Snow surveys are often conducted in teams of 2-3 for safety reasons. Standard snow courses consist of 10 snow core measurements across 1000ft. To sample a core, a surveyor will screw together segments of a snow coring tube and screw it vertically into the snow. Once the ground is hit, the surveyor removes the tube with the snow inside and weighs it. The weight of the tube is subtracted from the total to measure the snow's mass and theoretical water content. If there is remote equipment in the area, surveyors will also perform routine maintenance and calibration.

In 1925, hydrographers from the LADWP visited Dr. Church in 1925 to learn his techniques. Since then, the LADWP has measured the same 12 courses among the Cottonwood Lakes, Big Pine Canyon, Rock Creek Canyon, and the Mammoth Lakes Basins[8]. These strategically selected sites are representative of overall snowpack at specific areas and elevations and reduce the amount of sites to be collected. Surveyors ski, snowshoe, or ride snow cats to these designated sites. Back country cabins are often stocked in the summer for the most remote sites. When conditions permit, 3 surveys can be done daily[9].

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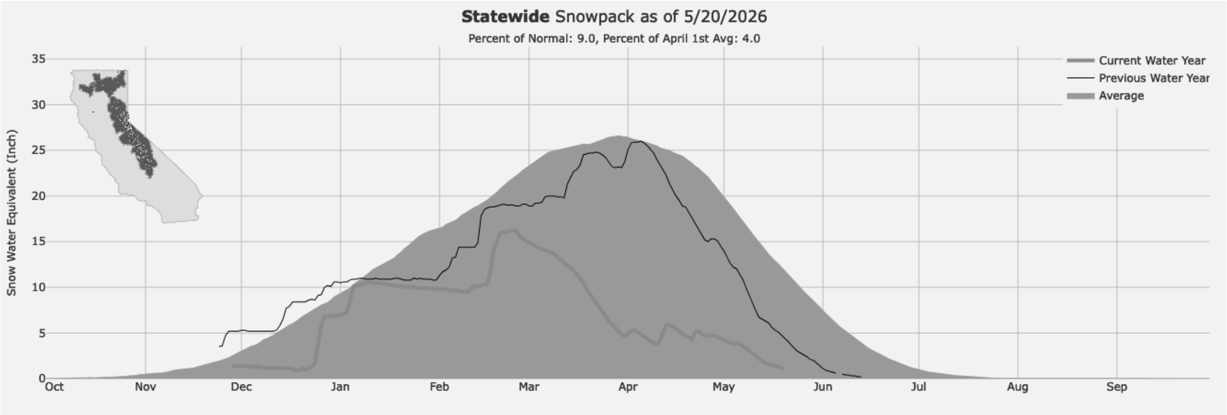
Across the Sierras, the CCSSP currently measures 280 sites each year among 40 partner organizations. These surveys occur primarily throughout January, February, and March. Life on multi-day, high-altitude back-country surveys was chronicled in Patrick Armstrong's, *Log of a Snow Survey*.



Automated Stations

In 1971, LADWP and the State of California began developing remote systems to collect backcountry snow data. The result was snow pillows[10] which is an instrument used to measure snow without a manual snow survey. Snow falls on a large platform, which depresses a large pillow of antifreeze solution. The pressure on the pillow is related to the water-equivalent of snow on top of the platform. Telemetry sites automatically update several times daily and relay data to a central collection site. Thus far, these stations have not replaced snow surveys entirely as frequent, manual calibration is still essential.

Remote/Satellite Sensing

Remote sensing promises to measure snowpack across regions that are too remote to survey by hand. It is performed by satellites or aircraft that estimate snow cover and snow water equivalent (SWE) from reflected light, microwave signals, lidar, or radar. However, satellite SWE remains inaccurate in deep, forested, wet, or melting snow, with large errors compared to ground-based estimates[11]. Active radar methods may improve resolution, but only work where snow is dry, vegetation is limited, and the signal can penetrate the pack[12]. The best results come from combining remote sensing, snow models, topography, and ground measurements, which is why snow surveys are still needed to calibrate instruments, validate estimates, and measure conditions that satellites cannot reliably resolve[13]. It is possible that drones may be able to perform remote snow pack measurements in the future.

Conclusion

Snow surveys continue as an essential part of hydrological estimates that ensure millions of people in California (as well as the rest of America, Europe, and Asia) allocate water appropriately and consistently.

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(16) Milankovitch Cycles and Sierra Glaciation — *Rachel Nazareth*

Milankovitch Cycles & Glaciation Chronology

Ge 136c Field Report — The Sierra Nevada — Rachel Nazareth — May 2026

Introduction

Geomorphological evidence for glaciation in the high-altitude Sierra Nevada is everywhere, from deep U-shaped valleys to polished granite. While ∼1000 small glaciers are currently found in the crest of the range, the Pleistocene epoch saw the range covered by more than 20,000 square kilometers of ice, about three orders of magnitude larger than the present! (Moore & Moring 2013). This disparity raises an interesting question: beyond greenhouse-gas concentrations, what drives Earth's cycles of warming and cooling?

In the early 1900s, Serbian scientist Milutin Milankovitch hypothesized that the answer came from orbital dynamics. He suggested that changes in Earth's relative position with respect to the sun could be the drivers of long-term climate patterns, especially periods of heavy glaciation (colloquially known as 'ice ages'). The Milankovitch theory proposes that three parameters—eccentricity, obliquity, and precession—govern the growth of ice sheets by modulating Northern Hemisphere summer insolation (NASA).

- **Eccentricity (∼100 ka):** Variation in the shape of Earth's orbit, changing from elliptical to quite circular.
- **Obliquity (∼41 ka):** Changes in axial tilt, varying from 22.1° to 24.5° with respect to the ecliptic.
- **Precession (∼23 ka):** The axial and apsidal "wobble" pattern; a change in where the poles point relative to the stars.

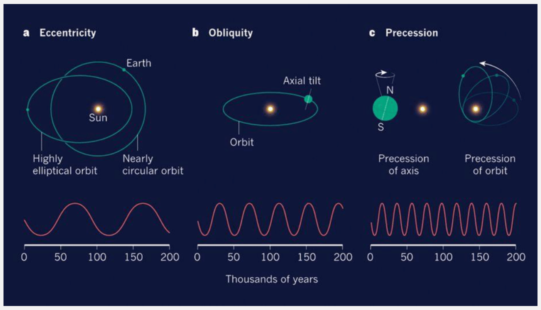

Figure 1: Idealized cyclical changes in orbital parameters (NASA). Note that changes are exaggerated.

Insolation Patterns

The orbital parameters operate on different timescales and overlap in complex rhythms, so they can both reinforce and offset the climate impacts of each other, depending on their combination.

Eccentricity: A higher eccentricity causes global temperature differences at different points in Earth's orbit. A nonzero eccentricity alters the length of different seasons; currently, the northern hemisphere's summer is 4.5 days longer than its winter. Earth achieves perihelion on January 3 and aphelion on July 4, so the planet receives 6.8% more insolation globally in January than it does in July. However, at Earth's highest recorded ellipticity, 23% more insolation will occur at perihelion than aphelion.

Obliquity: Earth's axial tilt is currently about 23.4°, halfway between extremes. A greater tilt angle makes seasons more extreme, whereas a smaller tilt angle keeps temperatures more consistent throughout the year. Although high obliquity creates colder winters, glaciation favors low obliquity because cooler summers allow snow and ice to build up instead of fully melting. At that point, ice sheets increase Earth's albedo and cause further cooling. However, axial tilt creates non-uniform distribution of insolation, so effects are larger at high latitudes.

Precession: Even at the same obliquity, Earth's axis precesses like a spinning top. Depending on when solstices and equinoxes occur relative to perihelion and aphelion, precession can affect seasonal timing. This amplifies seasonal contrasts in one hemisphere while minimizing them in the other. Currently, Earth passes through perihelion during the northern hemisphere's winter, so the northern hemisphere has more moderate seasonal variations in comparison to the southern hemisphere.

Overall, minimal glaciation occurs when obliquity and eccentricity are high and the summer solstice occurs near perihelion, producing maximum insolation (see Figure 2). Conversely, maximum ice volume occurs when low obliquity, extreme eccentricity, and a summer solstice near aphelion produces minimum solar insolation (NASA; NOAA Climate). Glaciation is also affected by other factors like carbon dioxide levels and local precipitation patterns. Even in a cold phase, Sierran glaciers can only reach peak volume if Pacific moisture delivery is sufficient. However, Rood et al. (2011) suggests that Sierran glacial chronology correlates fairly well with global insolation and ice volume patterns.

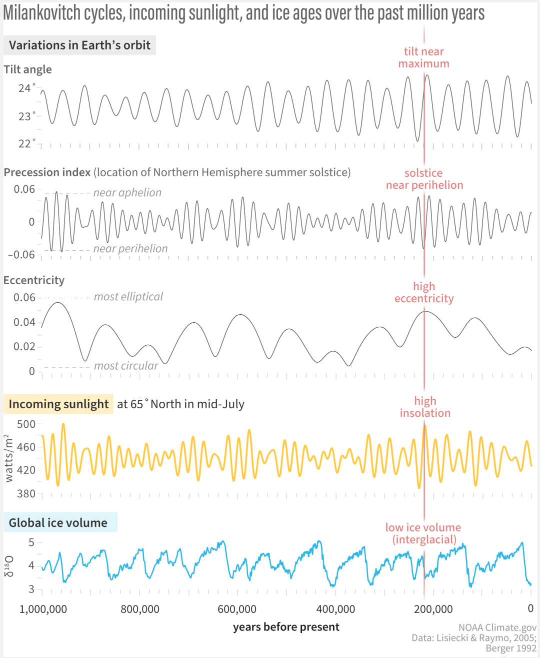

Figure 2: Milankovitch cycles, solar insolation, and global ice volume (NOAA Climate). Data from Lisiecki & Raymo (2005) and Berger (1992).

Marine Isotope Stages (MIS)

One way to represent alternating ‘warm’ and ‘cool’ periods in Earth’s paleoclimate is with Marine Isotope Stages, which are deduced from oxygen isotope ratios in deep-sea sediment. During glacial periods, widespread ice sheets preferentially take up lighter ^{16}O rather than ^{18}O. The stages are numbered, starting from 1 (the present) and working backwards, with even stages the glacial periods and odd stages the interglacial periods. Marine isotope stages can be combined with astrochronology – that is, predicted solar radiation curves from back-calculated orbital geometry – to confirm Milankovitch periodicities and their effects on global ice volume (Elias 2025).

Bridging Global to Local

To take a global cycle and apply it locally, we compare **Cosmogenic Nuclide Dating** of Sierran rock samples to our baseline Marine Isotope Stages. Rare isotopes like ^{10}Be, ^{26}Al, and ^{36}Cl are produced when cosmic rays strike surface rocks. Since nuclide production rates are known, geologists can infer how long rocks resided on/near the surface by measuring nuclide concentrations (Bierman et al. 2021). Glacial retreats can be dated and compared to marine isotope stages to determine if glacial behavior corresponded to global climate patterns associated with Milankovitch cycles.

Table 1: Glacial Chronology (Moore & Moring 2013).

Stage	Age (ka)	MIS Stage
Recess Peak	13	MIS 1–2
Tioga	14-28	MIS 2
Tenaya/Tahoe II	70	MIS 4
Tahoe	130-170	MIS 6
Sherwin	820	MIS 20

Sierra Nevada Glaciers

The Sierra Nevada’s glacial features were largely carved/deposited between MIS 2 and MIS 6, by the principal Pleistocene glacial stages of **Sherwin, Tahoe, Tioga,** and **Recess Peak**. These are *local* glacial periods that appear in the geological record of the Sierra Nevada. In Kings Canyon, we observe that the Kings Glacier reached a maximum length of 44 miles during the Tioga Stage, reaching elevations 6,000 feet lower than where glaciers form today (USGS). The massive volume of ice was responsible for the geomorphic transition from a fluvial V-shaped valley to the iconic U-shaped trough visible today (NPS).

Of these four principal glacial stages, three of them—Sherwin, Tahoe, and Tioga—correspond well with Milankovich-associated global cooling periods. The Tioga period is considered the **“Last Glacial Maximum,”** or LGM, and is the best-preserved example of glaciation in Kings Canyon as well as Sequoia and Yosemite National Park. Others (e.g. Sharp & Birman 1963) also include intermediate pre-LGM periods such as **Tenaya**, which is otherwise considered part of the larger Tahoe glaciation.

Sherwin: Around MIS 20, Earth experienced a prolonged period of low obliquity, combined with high eccentricity (with aphelion-aligned summer). This occurred during the Mid-Pleistocene Transition, during which Earth’s ice age cycle switched from ∼41,000 to ∼100,000 year cycles. The cause of the transition is unknown, but theories include changes in atmospheric CO_2, ocean circulation, and/or glacial regolith.

Tahoe and Tenaya: As with Sherwin, the Tahoe (MIS 6) and Tenaya (MIS 4) glacial stages occurred during a period of low obliquity, high eccentricity, and aphelion-aligned summer.

Tioga: The Tioga glaciation (MIS 2) occured during a period of low eccentricity and low obliquity, with the cooling primarily driven by the milder seasons created by the low axial tilt.

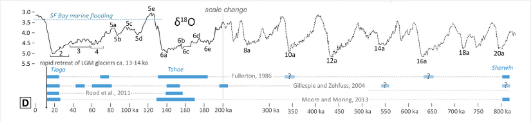

Figure 3: Chronology of Sierra Nevada glacial cycles under ^{18}O MIS curve. Sourced from Sickmann & Malkowski (2024).

Recess Peak: An Exception

The Recess Peak readvance was much smaller-scale than the Tioga stage, with glaciers re-growing in high-altitude cirques during the late-glacial to early Holocene transition. Interestingly, it does not appear to align with global cooling periods associated with Milankovitch cycles. The Recess Peak glaciation co-occurs with late MIS 2 to early MIS 1, during a period of *increasing* insolation. Since it also does not correspond with a significant peak in the ^{18}O record, it was likely driven by regional climatic factors. It is sometimes associated with the Younger Dryas, an abrupt cooling event caused by the disruption of the Atlantic Meridional Overturning Circulation (AMOC). However, the Recess Peak readvance may pre-date the Younger Dryas (Phillips 2016). Clark and Gillespie (1998) suggest that North America had a variable climate in this period; the regional phenomena may have been caused by changes in moisture delivery, such as shifts in Pacific storm tracks that produced additional high-altitude snowfall.

Melting in the Holocene

The Holocene epoch, beginning ∼12,000 years ago, represents the current interglacial period. Following the retreat of Tioga-stage glaciers, Sierran glaciers completely or near-completely disappeared as temperatures peaked during the Holocene Thermal Maximum. Small neoglacial advances have occurred since, but they are small in comparison to Pleistocene scales.

Although our current orbital configuration should favor a *cooling* trend in the Northern Hemisphere, current melting rates are driven by higher greenhouse-gas concentrations. The current CO_2 concentration is ∼420 ppm. If levels remain around 400 ppm, another ice age will not occur for ∼125,000 years. If levels rise to 560 ppm, no Milankovitch variation can trigger a glacial period for at least half a million years (NOAA Climate).

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(17) Boyden Cave & the Kings Canyon Roof Pendant — *Koki Yoshioka*

Boyden Cave Roof Pendant

Koki Yoshioka

1. What is Roof Pendant?

A roof pendant is a mass of the older country rock preserved (often) above the plutonic intrusions. The first step of its formation is the conversion of pre-existing sedimentary basement rock into metamorphic rock through contact metamorphism by the plutonic intrusion. The uplift and the erosion expose the portion of the metamorphic rock hanging above the plutonic intrusion (Figure 1). This exposed portion of metamorphic rock on top is the roof pendant. Hence, the roof pendant can tell us about the pre-batholith history of the region (for the case of Sierra Nevada).

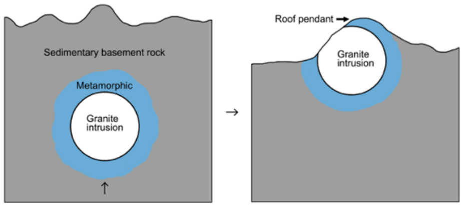
Sedimentary basement rock
Metamorphic
Granite intrusion
→
Roof pendant
Granite intrusion

Figure 1. Formation of a roof pendant. Credit: Wendy Van Norden.

2. Geology of Boyden Cave Roof Pendant

In the Sierra Nevada, the most abundant bedrock material is the granitic rocks. However, as previously explained, remnants of pre-batholithic metamorphosed sedimentary (and volcanic) rocks exist as roof pendants. One of the largest areas of such rocks in the region is the Boyden Cave roof pendant. The Boyden Cave roof pendant is geologically significant in that (1) preserves the pre-batholith continental margin, (2) preserves the Jurassic deformations, (3) can be used to study metamorphism and plutonism. I will explain these in a little more detail in the following section by focusing on the mineralogy, the structure, and the history.

2.1. Mineralogy and Age

The roof pendant consists of two terranes: the Kings terrane (metasedimentary, to the west) and Goddard terrane (metavolcanic, to the east). The former consists of highly deformed and metamorphosed quartzite, arkose, marl, mudstone, calcareous sandstone, and limestone [1]. Fossils, mainly crinoids and ammonites can be found, and this area is thought to be from the Late Triassic to Early Jurassic age [1]. The latter mainly consists of meta-dacite and tuffs [1]. The Rb-Sr and U-Pb zircon isotopic dating of the metavolcanic rocks suggest ages of 102-105 Ma (mid-Cretaceous) [2].

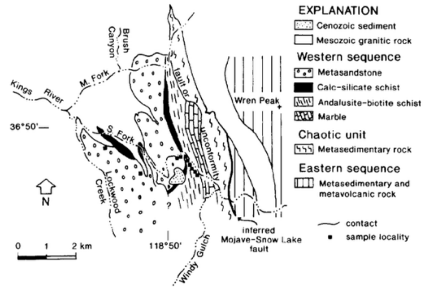
EXPLANATION
Cenozoic sediment
Mesozoic granitic rock
Western sequence
Metasandstone
Calc-silicate schist
Andalusite-biotite schist
Marble
Chaotic unit
Metasedimentary rock
Eastern sequence
Metasedimentary and metavolcanic rock
contact
sample locality
Brush Canyon
Kings River
M. Fork
36°50'
S. Fork
fault or unconformity
Wren Peak
Lockwood Creek
N
?
0 1 2 km
118°50'
Windy Gulch
inferred Mojave-Snow Lake fault

Figure 2. Geologic map of Boyden Cave.

2.2. Geological Structure

The rocks of the King terrane are heavily and complexly deformed and regionally metamorphosed [3]. A couple of minor and major structure are recognized, the “first-generation structure” and the “second-generation structure”, each with distinctive style and average strike of axial planes and faults (FIGURE2). The first-generation strikes east-northeast and dips north, while the younger structure strikes north-

northwest and dips steeply to vertically [1]. The first-generation structure is thought to have formed during the Early or Middle Jurassic and the second during Late Jurassic to the mid-Cretaceous [4]. The metamorphosed volcanic rocks in the Boyden Cave roof pendant only shows second-generation.

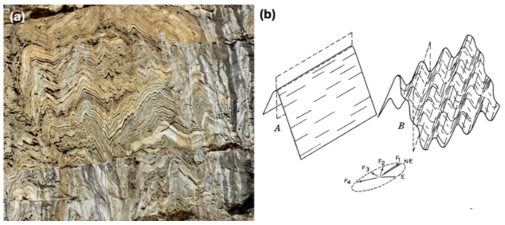

Figure 3.(a) Heavily deformed layers of rocks of the Kings Terrane. Credit: Garry Hayes. (b) A, First-Generation fold (F1) and B, Second-generation fold (F2) [5].

2.3. Geological History

As implied in 2.1 and 2.2, the history of the region can be roughly summarized into three stages: (1) the formation of sedimentary rocks and volcanic rocks in a subduction-zone setting, (2) the deformation and metamorphism during the Nevadan orogeny, and (3) intrusion of Sierra Nevada batholith. The earliest rocks to have formed were the quartz-rich sandstone, shale, and carbonate sediments around passive margin during late Paleozoic to Triassic [6], followed by set of felsic volcanism that deposited tuff e.t.c.. During the Jurassic, subduction intensifies and due to the Nevadan Orogeny, the complex structure of folds and foliation were created [7]. Finally, during the Late Jurassic to the Cretaceous, the granitic plutons intrude to the region and metamorphose the existing sedimentary and volcanic rocks and eventually forming the roof pendant via uplifting and erosion.

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(18) Glacial Geomorphology: Arêtes, Cirques, Glacial Lakes and Moraines — *Elin Stenmark*

Glacial Geomorphology Features

Elin Stenmark, Ge136c, 2026

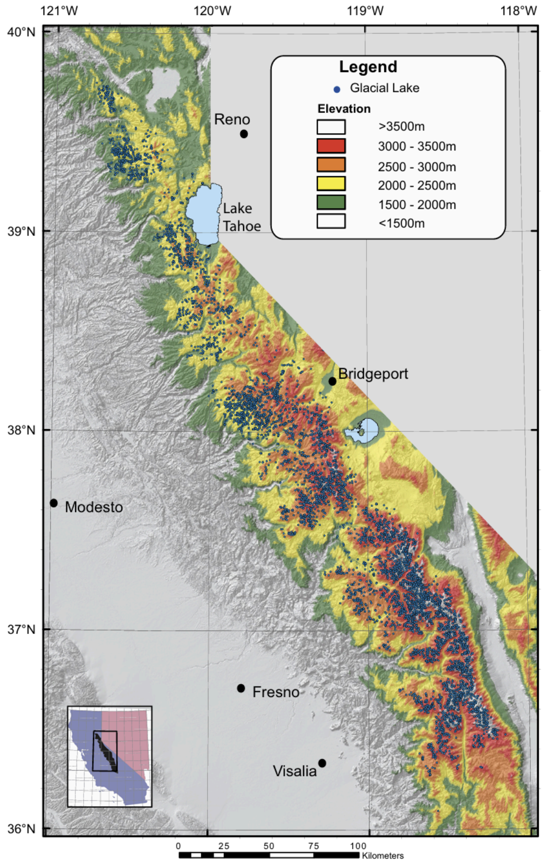


Figure 1. Map of eastern California showing topography of the Sierra Nevada with glacial lakes shown by blue dots. The lakes were exposed and formed at the retreat of the final Tioga glacial stage. Note that the elevation of the range and the width, elevation, and density of the lake zone decrease toward the north.

Adapted from Moore and Moring (2013).

Glaciers are dynamic masses of snow, firn (compact snow), and ice, often containing rock and meltwater [Hagg, 2022]. The movement of glaciers to erode and deposit rocks drastically alters landscapes and produces distinct glacial landforms. For historical reasons, there are three main classification systems used to delineate glaciers: the source of their nourishment, their morphology, and their thermal profile [Hagg, 2022].

Examples of glacial geomorphology:

Arêtes are sharp central mountain ridges that form when two cirques or glacial valleys erode material in parallel from opposite sides of the ridge.

Cirques are bowl-shaped depressions caused by glacial flow.

Glacial Lakes are an accumulation of standing water on top of, inside, or under a glacier.

Horns are formed from the erosion by several cirques, often tetragonal or pyramidal. A horn with four symmetrical faces is known as a Matterhorn.

Ice tongues are long, narrow, overhanging ice sheets formed at the terminator of valley glaciers flowing into water.

Morraine is a term describing a landform made up of debris moved by a glacier, as well as sediment deposited at the glacier margin.

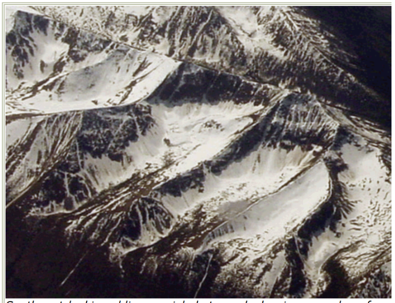
Nunataks are ridges, such as horns, which protrude through a glacier.

Striated clasts are larger-sized clasts which can retain linear scratches across their surfaces, due to scraping by basal debris lodged at the ice-sediment boundary.

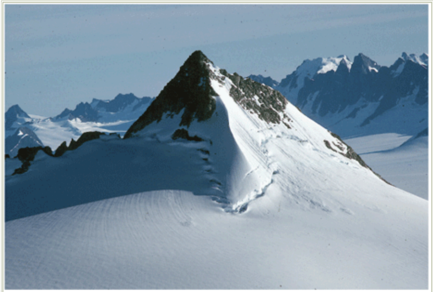
Till is a characteristically unsorted and poorly stratified sediment [Molnia, 2004]. The corresponding lithified sedimentary rock is referred to as a tillite.

Valley glaciers: Since glaciers flow along the path of least resistance, they often occupy V-shaped valleys carved by rivers. As glaciers erode the entire cross-section of valleys, erosion produces distinctive U-shaped valleys.

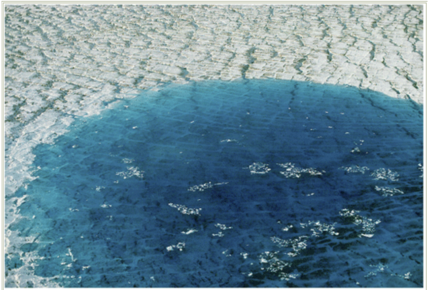
For a more complete list of glacier terminology, along with definitions and example images, see: https://pubs.usgs.gov/of/2004/1216/index.html and the Glossary section of [Hagg, 2022]



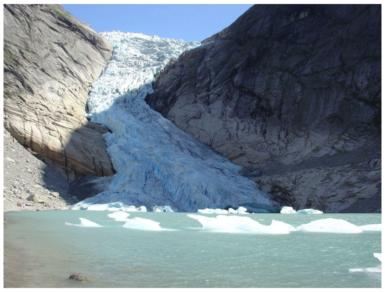
Southwest-looking oblique aerial photograph showing a number of snow-covered cirques, cut into the summit of a Coast Mountains ridge along the Alaska - Canada border, east of Glacier Bay National Park, Alaska. Note the uniform snowline.

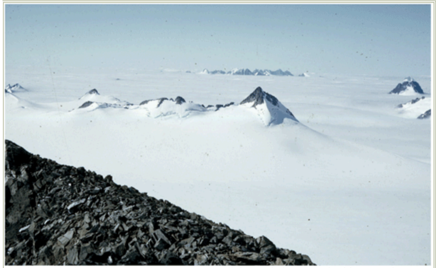


Northeast-looking photograph showing a well-formed sharp-peaked horn on the Juneau Icefield, Tongass National Forest, Alaska. Bergschrunds delineate the heads of the two glaciers located on the southeast and southwest sides of the horn. Note the arete ridge on the west side of the horn.

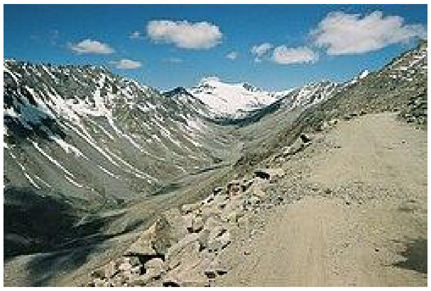


July 1995 oblique aerial photograph of most of a circular, blue water, supra-glacial lake on the surface of Bering Glacier, the largest Alaskan glacier, located east of Cordova. The lake formed during the 1993-95 surge of the glacier. The lake has a diameter of ~ .5 miles. Bering Glacier flows through Wrangell-Saint Elias National Park. Chugach Mountains, Alaska.





Northeast-looking photograph showing a well-formed sharp-peaked horn and connected arete ridge. The horn which pokes through the snow-covered Juneau Icefield is a nunatak, Tongass National Forest, Alaska.



Images with figure captions are taken from the USGS Glossary of Glacier Terminology [Molnia, 2004].
Glacial tongue (lower left): Wikimedia Commons. U-shaped valley (lower right): Wikipedia.

History of the Sierra Nevada glacial geomorphology: During the Pleistocene, the northern 490 km of the 600 km long Sierra Nevada mountain range was covered by over 20,000 km^2 of glaciers [Moore & Moring, 2013] to produce some of the aforementioned geomorphologies we observe today. The glacial geochronology itself is complicated by a lack of volcanic deposits, erosion of older morraines by younger features, and preferential erosion of steep canyons following glacial retreat [Moore & Moring, 2013].

Present-day glaciation: The Sierra Nevada region is currently host to cirque glaciers, which are thought to be the result of a recent 'Little Ice Age' between the years 1450-1850 [Miller, 2015]. Cirque glaciers form inside cirques; the high walls cast shadows which limits the glacier's sun exposure to reduce sublimation. These ice deposits are located at an elevation exceeding 3250 m [Moore & Moring, 2013]. Extrapolating the mean glacial retreat rate between 1972 and 2004, the glaciers are predicted to vanish within 50-250 years [Basagic & Fountain, 2011]. This loss constitutes a depleted reservoir for summer meltwater supply, as well as increased river temperatures.

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(19) Granite Exhumation and Weathering Styles — *Waqar Mirza*

Granite Exhumation and Weathering in the Western Sierra

Waqar Mirza — GE 136C Report

Overview

Granite is an intrusive igneous rock (plutonic rock) that forms miles beneath Earth's surface as magma cools slowly under high pressure. In the Sierra Nevada, these rocks crystallised as part of the Sierra Nevada batholith and were later exposed by tectonic uplift, erosion, and canyon incision, a process known as **exhumation** [1,2]. Once near the surface, pressure release and changing stress conditions fractured the granite into joints and sheets. These cracks then guided **weathering**: the breakdown of rock by water, ice, and chemical alteration into exfoliation slabs, angular blocks, sandy grus, and rounded corestones.

1. Exhumation: from pluton to outcrop

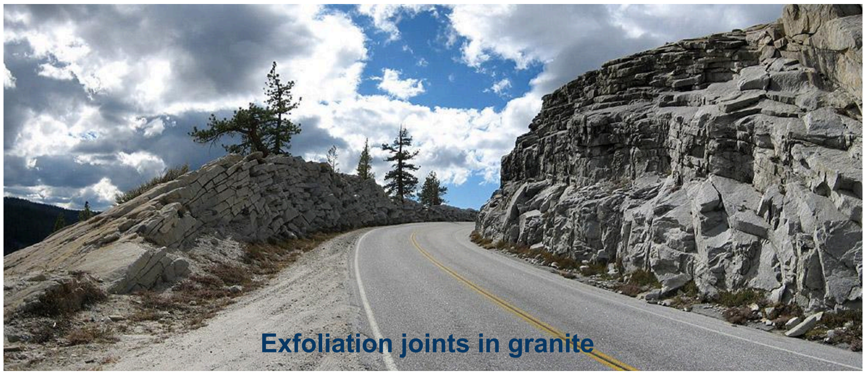
Exhumation refers to the removal of overlying rock until formerly deep rock is exposed at or near the surface. In the Sierra Nevada, this involved erosion of volcanic and metamorphic cover, uplift of the range, and incision by rivers and glaciated valleys [1,2]. Exhumation also changes the stress conditions around granite. As confining pressure decreases and topography develops, joints can open or propagate. Thus, exhumation does more than reveal granite: it helps establish the fracture network that later controls weathering.

2. Joints control the weathering pattern

Fresh granite is strong, but jointed granite is vulnerable. Fractures create pathways for water, roots, ice, oxidation, and chemical reactions. They also define the size and shape of blocks that can be removed by rockfall or rounded by weathering. This is why the same granitic bedrock can appear as smooth slabs, blocky cliffs, coarse sand, or rounded boulders.

3. Exfoliation and sheet joints

Exfoliation is the separation of curved sheets or slabs from near-surface granite. These fractures are often called sheeting joints because they tend to form roughly parallel to the land surface. The simple explanation is unloading during exhumation: as overlying rock is removed, near-surface granite expands and fractures. A better modern view is that sheeting is a stress-controlled fracture process involving unloading, topography, regional stress, thermal effects, and pre-existing weaknesses [3].



Source: https://commons.wikimedia.org/wiki/File:Exfoliation_joints_granite_yosemite.jpg

4. Granite sand and grus

Grus is the coarse sandy material produced when granite disaggregates grain by grain. Granite minerals weather at different rates: feldspar alters to clay minerals, biotite oxidises and hydrates, and quartz commonly survives as sand-sized grains. The rock can become weak and sandy while still preserving its original granitic texture [4,5]. This links upland granite weathering to lower-elevation sandy soils, stream sediment, and alluvial deposits along the western Sierra margin.

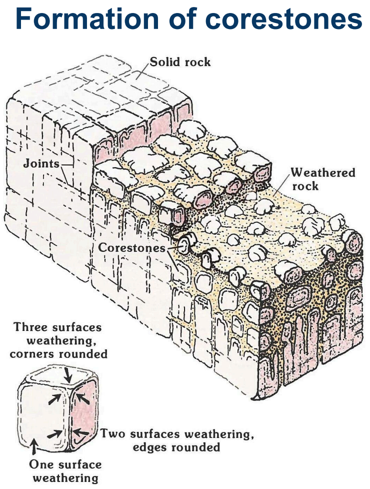
5. Freeze-thaw jointing

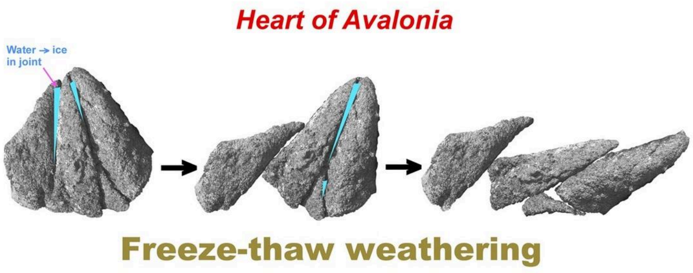
At higher elevations, water entering cracks can repeatedly freeze and thaw, helping widen joints and detach angular blocks. Frost cracking is most effective where water is present, and temperatures cycle around freezing.

In the field, it tends to produce sharp blocks, talus, widened joints, and fractured slabs rather than rounded boulders. This gives a broad elevation contrast: colder upper-Sierra settings favour joint widening and angular debris, while warmer or soil-covered lower settings more commonly favour chemical alteration, grus, and corestones.

6. Spheroidal weathering

Spheroidal weathering occurs when joint-bounded blocks chemically weather from the outside inward. Corners weather fastest because they are attacked from three directions, edges from two, and faces from one. The result is a rounded corestone surrounded by weathered rind or saprolite [6]. This is different from exfoliation: exfoliation removes surface-parallel slabs, whereas spheroidal weathering rounds individual blocks along intersecting joints.





Sources:
Left:https://commons.wikimedia.org/wiki/File:Weathering_of_joint_blocks_and_stages_in_the_formation_of_corestones.jpg,
Right:https://www.heartofavalonia.org/freeze-thaw.html

Summary of main weathering styles

Process	Description	Landforms Created
Exfoliation/sheeting	surface-parallel stress fractures	smooth domes, curved slabs
Grusification	mineral alteration + grain-scale disaggregation	coarse decomposed granite sand
Freeze-thaw cracking	water-ice cycling in joints	angular blocks, talus, widened cracks
Spheroidal weathering	inward alteration of joint-bounded blocks	rounded corestones and weathering rinds

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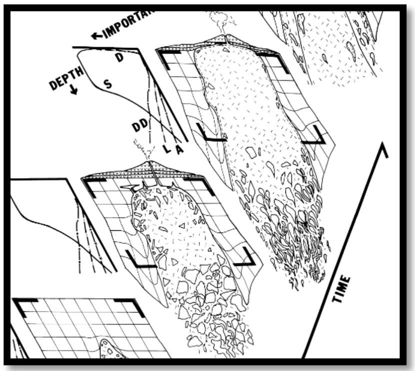
Ben J. Thyer
Ge 136c: West Sierra Nevada

The Sierra Nevada as a Battleground in the War Against Magma Chambers

I. The Traditional View and Its Challenges


←IMPORTANT
DEPTH
D
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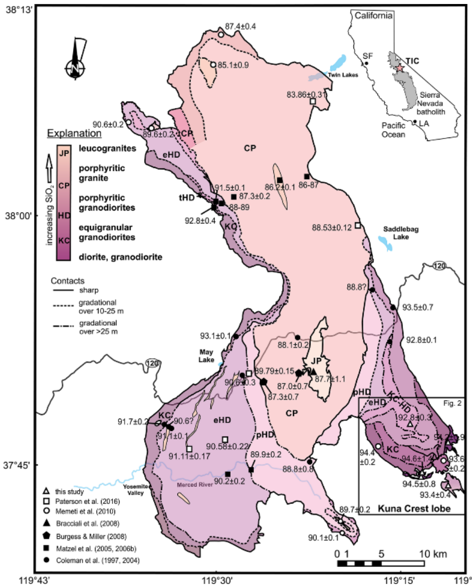
TIME

A beautiful schematic of 'stoping', wherein a pluton advances by eroding the roof above (Paterson and Vernon, 1995). Stoping requires high melt fractions and low viscosities.

For much of the twentieth century, the dominant model of pluton emplacement invoked large, largely molten magma blobs ascending through the crust by diapirism, ballooning, or stoping: processes that require melt fractions of at least ~50 vol% to permit bulk flow (Marsh, 1981). These processes were often difficult to reconcile with physical models. For example, the characteristic high viscosity of granitoids makes stoping difficult, and the typical estimated speeds of granitic diapirs (10^-7 cm/sec or mm's per year, Marsh, 1984) only allow permit large diapirs to travel at most 1-5 km before rheological lock up. Additionally, as geophysical imaging technology improved, surveys of active volcanic systems rarely detected melt fractions exceeding 10–20%, and they typically show melt dispersed in dikes and veins rather than concentrated in large, round blobs (Glazner et al., 2004, Wilding et al., 2022). These paradoxes were brought to a head in the 2000s, when high precision U/Pb zircon geochronology began resolving plutons' internal thermal histories.

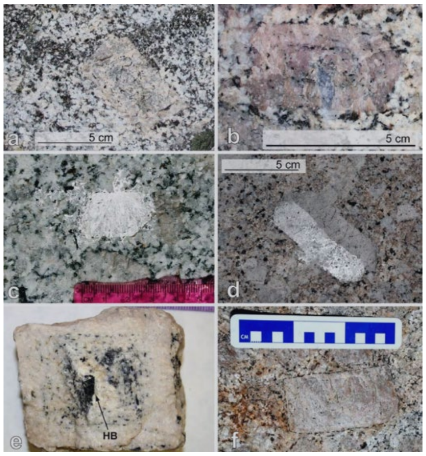
II. The Tuolumne Intrusive Complex: A Geochronologic Test Case

The ~1100 km^2 Tuolumne Intrusive Complex (TIC) of the Sierra Nevada batholith provides the clearest evidence that large plutons accumulate incrementally over geologically protracted timescales. The TIC is youngest on the inside and oldest on the outside: U/Pb geochronology records it was built continuously from ca. 95 and 85 Ma, with 4 million years within the Half Dome Granodiorite alone (Coleman et al., 2004). Simple thermal modeling demonstrates that a magma chamber the size of the Half Dome Granodiorite (~10 km half-width) would cool below zircon closure temperature (~900°C) in less than 1 Ma by conduction alone — far too fast to account for the observed age range (Coleman et al., 2004; Glazner et al., 2004). The


38°13'
38°00'
37°45'
119°43'
119°30'
119°15'
119°10'
N
Explanation
increasing SiO2
JP leucogranites
CP porphyritic granite
HD porphyritic granodiorites
KC equigranular granodiorites
diorite, granodiorite
Contacts
sharp
gradational over 10-25 m
gradational over >25 m
△ this study
□ Paterson et al. (2016)
○ Memeti et al. (2010)
▲ Bracciali et al. (2008)
⬟ Burgess & Miller (2008)
■ Matzel et al. (2005, 2006b)
● Coleman et al. (1997, 2004)
California
SF
TIC
Sierra Nevada batholith
LA
Pacific Ocean
Twin Lakes
Saddlebag Lake
May Lake
Yosemite Valley
Merced River
120
CP
eHD
tHD
KC
JP
pHD
KC-HD
Fig. 2
Kuna Crest lobe
87.4±0.4
85.1±0.9
83.86±0.31
90.6±0.2
89.6±0.2
91.5±0.1
87.3±0.2
86.2±0.1
86-87
88-89
92.8±0.4
88.53±0.12
88.8?
93.5±0.7
92.8±0.1
93.1±0.1
88.1±0.2
89.79±0.15
90.6±0.3
87.0±0.7
87.3±0.7
87.7±1.1
91.7±0.2
90.6?
91.1±0.1
90.58±0.22
91.11±0.17
89.9±0.2
88.8±0.8
90.2±0.2
92.8±0.3
94.4 ±0.2
94.6±1.4
93.6 ±0.2
94.5±0.8
93.4±0.4
89.7±0.2
90.1±0.1
0 1 5 10 km

Map of the Tuolumne Intrusive Complex (TIC) from Memeti et al., 2021. Older and more primitive granodiorite envelops younger and more evolved granodiorite. "Contacts" are gradual over 10's of meters and poorly defined. The ~10 Ma duration of assembly requires that only a small proportion of the TIC could be molten at a given time.

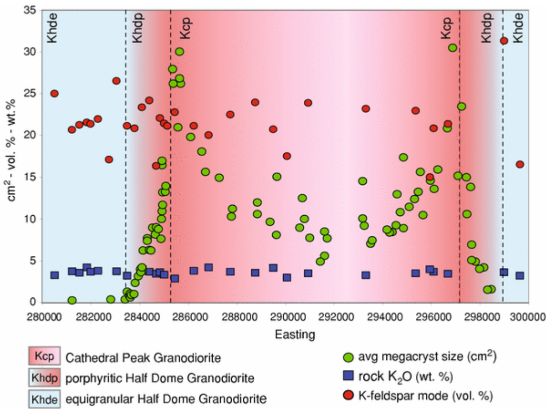
data therefore require that the TIC was assembled incrementally, probably as a series of dike- or sill-like pulses throughout the pluton, without having existed as a single magma chamber. This result is especially profound because there are no visible contacts within the Half Dome Granodiorite, implying that any pluton could be built in multiple episodes without leaving obvious field evidence, suddenly discrediting the anecdotal evidence that large plutons resemble blobby “fossil magma chambers”. Indeed, these revelations cast doubt on the very existence of large, unerupted magma chambers in the upper crust.



Field photos of Sierran K-Feldspar Megacrysts (Johnson and Glazner, 2009). They contain abundant late biotite and trace phase inclusions, which is not expected for crystal growth in a liquid suspension.

III. Implications for Paradoxical K-Feldspar Megacrysts

Few features of granodioritic plutons have generated more debate than K-feldspar megacrysts, abundant in the Cathedral Peak Granodiorite with massive crystals reaching 15 cm. The traditional interpretation holds that megacrysts attain their size by forming early and growing in a liquid-dominant magma. Yet, experimental work shows K-feldspar is a late crystallizing phase, only beginning to crystalize after ~30-50% or more of the liquid has frozen to other phases. This crystal fraction is close to the “critical” melt fraction, where abundant crystals form a rigid network and begin to behave rheologically as a solid. Furthermore, the liquid-suspension model predicts a correlation between abundance of K-feldspar megacrysts with K2O contents and total K-feldspar abundance, which is not observed. Johnson and Glazner (2010) propose instead that megacrysts grow by late-stage textural coarsening analogous to Oswald ripening, wherein temperature and melt fraction is cycled by successive, small magma influxes, preferentially dissolving smaller, higher-surface-energy K-feldspar crystals while nearby larger crystals grow at their expense. This neatly explains the decoupling of K-feldspar megacryst abundance with bulk K_2O composition as well as the high abundance of megacrysts at the margins of individual units where temperature fluctuations due to emplacement of successive magma pulses would be strongest.



A provocative figure from Johnson and Glazner, 2009. The K_2O and K-feldspar abundance is constant across the transition between the Half Dome and Cathedral Peak granodiorites, even while the abundance of K-feldspar megacrysts varies massively.

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Antibiotic Resistance in Cattle, Salmon, and the California Food Supply

Madi Tongco
Ge 136c 2026

Antibiotic use in agriculture started about 8 decades ago with the globalization of the livestock industry. Despite warnings of the likelihood of causing antimicrobial resistance (AMR) since the 1940s, antibiotics were viewed as a useful tool for cutting down on disease spread (often referred to as therapeutic use) and increasing productivity as growth promoters (non-therapeutic use) and are given in food, water, or via injection. An uptick in agricultural antibiotic use started in the 1970s, when feedlot systems became more common. Such antibiotics were often unapproved by the FDA and bought illegally; this led consumers to take more interest in organic food as well as push national governments to cut down on antibiotic use [1].

Figure 1. A cattle feedlot [2].

Too much antibiotic use in livestock farming runs the risk of multi-drug resistant (MDR) bacteria being spread between livestock as well as to humans via many methods, including using manure as fertilizer, consuming contaminated products, or through water systems and farming equipment. Antibiotic resistance can be developed intrinsically, through genetic mutations, or be acquired, through horizontal gene transfer (HGT). In HGT, genes are transferred between individual bacteria via conjugation (physical connection and transfer), transformation (picking up genes from the environment), or transduction (transfer through viral injection) [3].

Cattle in particular are able to host several MDR strains of *E. coli*, various *Salmonella* species, and *S. aureus*. 73% of the world's antimicrobial use is within livestock farming and occurs mainly in low- and middle-income countries, with MDR bacteria frequently observed even if there was limited antibiotic use in the farm. Cattle are often exposed to antibiotics when fairly young, which increases the possibility of MDR bacteria colonizing their immature gut microbiota [3]. Waste from farms poses a strong risk, as AMR genes are often detected at significantly higher levels than background soil; however, waste from swine and chicken livestock does show less AMR than waste from cattle and fish [4].

Figure 2. An offshore oceanic aquafarm [5].

Antibiotics in aquafarming is 5.7% of antimicrobial usage across the world, but use antibiotics more intensively than in other industries. In the oceanic phase, in which antibiotic use is more commonly used, AMR selection occurs quite close to the consumer (compared to fish grown in freshwater, whose fillets are generally not sold) [6]. Antibiotics are given to fish orally, through surface-coated or pelleted food, or through water immersion or injection [7]. In non-isolated aquafarms, antibiotics can select for resistance in the farmed fish while also leeching into nearby ecosystems and selecting for AMRs in the sediment, shellfish, and other wild fish [1]. Aquafarms are also prone to fish escaping, usually due to equipment malfunctions; especially for off-shore aquacultures where fish can escape into the ocean, this poses a large risk for wider AMR spread [8].

Across the world, many countries have been regulating antibiotic use in livestock. In 2006, the European Union banned antibiotics for growth promotion, and any therapeutic antibiotic use was highly regulated [3]. The United States Food and Drug Administration has regulations in effect to reduce the use of antibiotics for growth but does not address the misuse of drugs for possible disease prevention. In 2018, the state of California passed Senate Bill 27, which banned routine use of antibiotics in food-animal production and any use of antibiotics without veterinary prescription. While some studies have found a reduction in resistant bacteria (such as for *E. coli* involved in urinary tract infections), others have also found little to no change in AMR prevalence in California. In general, measuring the impact of this bill is quite difficult, as the California Department of Food and Agriculture does not publicly track quantities of antibiotics use. Still, this bill has inspired similar bills in other states and is a step in the right direction for prevention of further AMR spread from farming [9].

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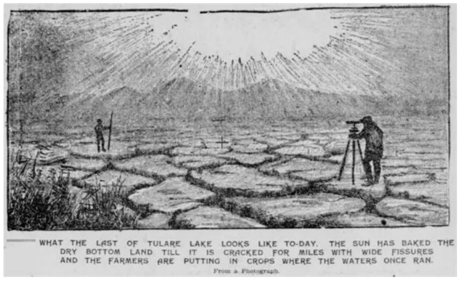
Pa’ashi: Impact of Dams on Pre-contact California Natives and Fauna

Ava Barbano, Ge 136c Spring 2026

Historical Environment & Indigenous Communities

Known as Pa'ashi, or “big water”, to the Tachi Yokut, Ancient Tulare Lake was once the largest freshwater lake west of the Mississippi River, covering up to 790 square miles in wet years [3]. Located at the southern end of California's San Joaquin Valley, the lake was shallow — only 39 feet at its deepest — with a shoreline that shifted dramatically by season and wind [2]. Dense tule marshes, willows, and buttonbush lined its shores, forming a wetland ecosystem spanning over 400,000 acres in the basin alone [3]. The name 'Tulare' is itself Spanish for tule marshes [2]. The Tachi Yokut built their culture around this lake for millennia, naming themselves after the tatsi (American coot), a bird that stayed year-round rather than migrating [7]. In their creation stories, the Tachi were made from the bottom of the lake itself, and its constant ebbs and flows are woven into their original songs and practices [12]. The lake was not merely a resource but a spiritual foundation: tribal members describe Pa'ashi as something living that provided for them.



WHAT THE LAST OF TULARE LAKE LOOKS LIKE TO-DAY. THE SUN HAS BAKED THE DRY BOTTOM LAND TILL IT IS CRACKED FOR MILES WITH WIDE FISSURES AND THE FARMERS ARE PUTTING IN CROPS WHERE THE WATERS ONCE RAN.
From a Photograph.

Drawing of Pa’ashi from the San Francisco Call, Volume 84, number 75, August 14th 1898.[12]

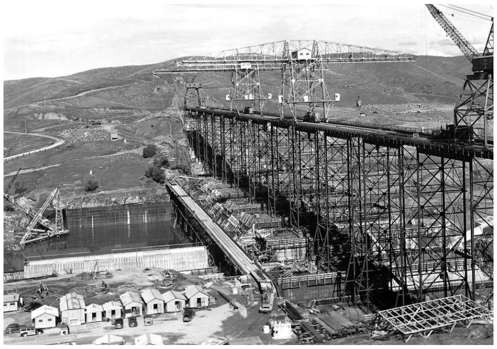
Pa’ashi, flood of 1938. Frank Latta papers, courtesy of the Huntington Library. [12]

Geographical and Hydrological Impacts of Human Intervention

Prior to European settlement, the Tulare Lake Basin functioned as a hydrologically closed system. Seasonal runoff from the Sierra Nevada collected in terminal lakes on the basin floor, shaped by tectonic subsidence and valley-crossing alluvial fans [3]. Annual lake levels fluctuated between 3–4 feet in normal years and 5–10 feet in wet years, capable of exposing or submerging more than 100 square miles of land in a single season [3]. The lake overflowed naturally into the San Joaquin River in 19 of the 29 years between 1850 and 1878, with the last recorded natural outflow occurring in 1877 [3]. Large-scale agricultural conversion beginning in the late 19th century replaced this dynamic system with engineered drainage. River channelization, diversion canals, and levee construction severed the lateral connections between rivers and their floodplains, eliminating the seasonal inundation that sustained tule marshes and wooded wetlands across the valley floor [3]. Friant Dam (1948) compounded these changes by regulating upper San Joaquin flows entirely, eliminating spring pulse flows that had historically flushed sediment downstream and maintained in-channel geomorphology [4]. Below the dam, gravel and sediment transport ceased, causing substrate coarsening and armoring of the streambed — conditions hostile to salmon spawning [4]. Hypolimnetic releases of cold, oxygen-poor water from reservoir depths further disrupted downstream temperature regimes [4]. Collectively, these interventions transformed the basin from a seasonally inundated, laterally connected wetland system into a tightly controlled irrigation network, eliminating the hydraulic variability on which both native species and Indigenous land use depended [3, 4].

Water Development and Colonial Dispossession

The construction of Friant Dam under the federal Central Valley Project was part of a broader pattern of federally subsidized water infrastructure that benefited agricultural landowners who had already displaced Indigenous communities. The dam blocked anadromous fish migration, inundated Sierra Nevada foothill habitat that had supported primarily native fish species, and introduced favorable conditions for non-native species that spread into native territory [4]. Each time the lake returned — after floods in 1969, 1983, and 1997 — it was intentionally drained to restore agricultural operations, repeatedly severing the Tachi Yokut from renewed access to their ancestral landscape [6, 7].



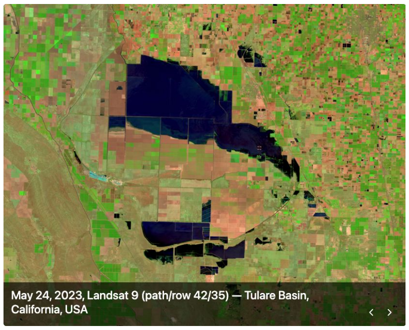
Friant dam construction [Friant Water Authority]

Impact on Fauna and Endangered Species

Prior to European settlement, the Tulare Lake ecosystem supported extraordinary biodiversity. Large mammals included grizzly and black bears, tule elk, pronghorn antelope, gray wolves, mountain lions, beavers, and river otters. The lake was a critical stop along the Pacific Flyway, hosting hundreds of thousands of migratory waterfowl including pintail ducks, sandhill cranes, geese, swans, and curlews. Fish populations included Sacramento perch, and during high-water overflow years, Chinook salmon and sturgeon entered the system [6]. Friant Dam eliminated the last population of spring-run Chinook salmon in the upper San Joaquin River by blocking access to cold upstream habitat where the fish overwintered between spring arrival (March–May) and autumn spawning, and by cutting off the spring flows needed for downstream juvenile migration [4]. Fall-run Chinook were likewise extirpated from the San Joaquin mainstem. Populations in the Merced, Tuolumne, and Stanislaus rivers collapsed due to blocked migration corridors and fine sediment accumulation over spawning gravels [4]. By 1990, fewer than 1,000 adult salmon were counted across the entire San Joaquin drainage [4]. The Tulare Basin Wildlife Management Area today supports seven threatened and endangered species, a reduced but still significant remnant of historical diversity [5]. Full recovery of native fish populations is highly unlikely under current water management conditions [4].

The 2023 Resurgence and Current State of Pa'ashi

A wet 2022–23 winter brought Pa'ashi back once more. At its peak in early June 2023, the lake reached approximately 178 square miles with depths of 5–7 feet, fed primarily by the Kings River, with significant contributions from the Kaweah, Tule, and Kern rivers [6]. The return of standing water immediately attracted wildlife: migratory waterfowl reappeared, and the tatsi were seen on the water in numbers not observed during years of drought [7]. For the Tachi Yokut, the event carried deep significance. Vice Chairman Robert Jeff stated: 'Pa'ashi has reawakened — at the same time, it's reawakened a lot of spirits' [7]. Tribal members held ceremonies on the lakeshore and resumed traditional hunting and fishing practices for the first time in years [8]. Unlike previous returns, tribal leaders and environmental advocates have called for the lake to be allowed to remain rather than being drained, arguing it would provide critical water storage and allow the region's native ecosystem to reestablish itself [7]. The 2023 resurgence has renewed public and scientific attention to whether the long-standing prioritization of agricultural land use over ecological and Indigenous restoration can, and should, be reconsidered.


May 24, 2023, Landsat 9 (path/row 42/35) — Tulare Basin, California, USA
‹ ›

2023 flood high water level [2]

Tachi & others celebrating return of Pa’ashi [7]

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(23) Field Guide to Plants of the High and Low Sierra — *Maia Hannahs*

Plants of the Upper & Lower Western Sierras

Maia Hannahs 2026 GE136c

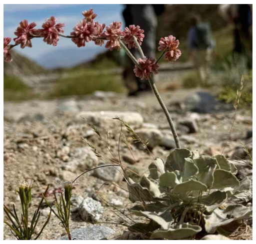
Key and definitions

▲Chaparral and higher altitude locations (you'll probably see these in the mountains around Mono springs)

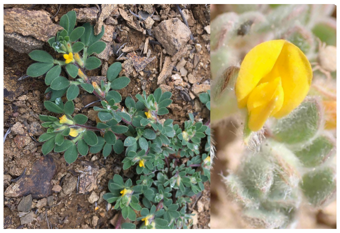
▼: Low altitude and river valleys (you'll probably see these in Kernville along the river)

🌱: Endemic — only exists in this local biome (sierra nevadas)

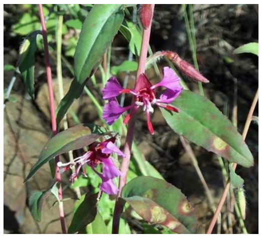
🌿 : Native — species originated in the region and it grows wildly



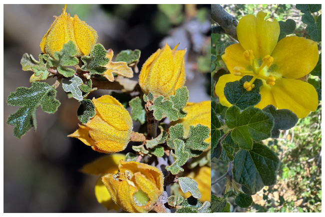
Rock Buckwheat (eriogonum saxatile)🌱▼ grows in dry and rocky areas Sierra Nevadas to. Grows as a ground mat of wooly scoop shaped leaves with a stalk of either red or yellow flowers. this can split at the groupings (inflorescence) or flowers in the plant. The genus contains several species of wild buckwheat native to the western US.



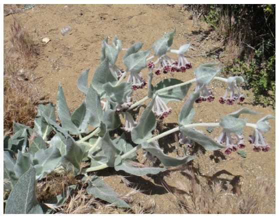
Bishops lotus (Acmispon brachycarpus)🌱▼ Grows in chaparral and dry woody areas. Within the Legume family (Fabaceae). Goes along the ground with symmetrically compound, fleshy leaves with 4-9 leaflets covered with fuzz. Pods often appear in pairs with a slight curve.



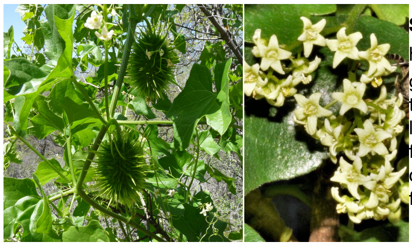
Elegant Clarkia (Clarkia unguiculata) 🌿▼ Smooth red stem with few alternating oval leaves, flower is attacked by short fuzzy stem. The flower has 4 shovel shaped petals and 8 stamens. This flower is often included in native wild flower mixes and important for pollinators, it is the host plant for the Mariposa forester butterfly



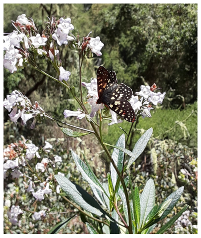
Flannel Bush (Fremontodendron californicum) 🌿▼ grows in sandy soils near water sources in chaparral and woodlands. It can range from 8 to 18 ft in size with fuzzy (hence the name) palmately lobed leaves. In springs it has striking 5 petaled yellow flowers and is important to pollinators.



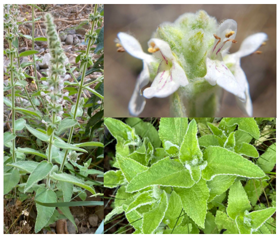
California Milkweed (Asclepias californica) 🌱▼perenial which occurs up to 7000 ft in elevation with thick white wooly stems that run along the ground with opposite leaves with a thick center vein. Flowers occur in bunches with five petals which bend sharply back with bulbs stamens



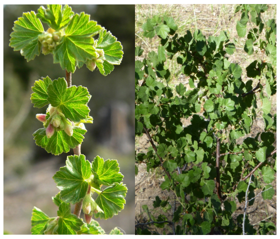
Sierra manroot (marah horrida)🌱▼ A lowlands growing vine with climbing tendrils and alternating lobed leaves, grows a dense spiny fruit, flowers occur on compound stems with 5 fused petals.



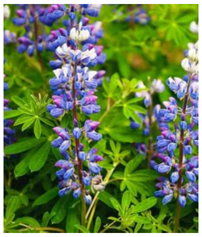
Yerba Santa (Eriodictyon californicum) 🌱▼Can exist along coast and upper mountains needs temperate weather and woody areas. Leaves are dark green, narrow leathery leaves which have serrated edges. The stems are reddish and waxy. It is the primary nectar source for several butterflies



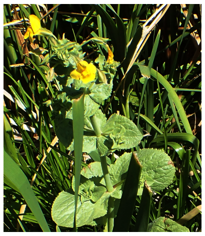
Whitestem Hedgenettle (Stachys albens) 🌱▼ small shrub in the mint family, thus the opposite leaves and the square cross-sectioned stem which is common to the family. Flowers are tubular, white and grow in circular clusters.



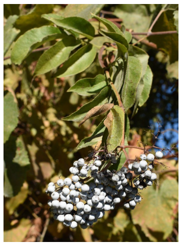
Wax Currant (Ribes cereum) 🌿▼ Compact shrub which grown in dry well drained soil. The leaves are shallowly lobed with serrated edges covered with glandular hairs, the pink flowers are five petaled and tubular. The red fruits are edible.



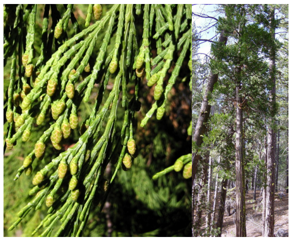
Lupines (Genus) 🌿▼ ▲ Species are native across the world, but the sierras are a center of diversity. The stalk of flowers in pink, white, or purple. The leaves are palmate (attached to the stem like the palm to a wrist) with 5-9 leaflets. The flowers and seeds (beans) are edible and an alternative to soy.



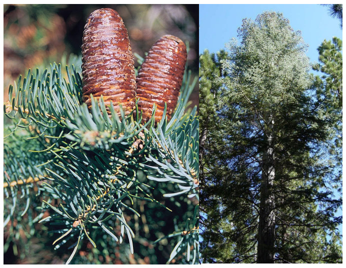
Seep Monkeyflower (Erythranthe guttata) 🌿▼ this small flowering plant grows in serpentine rich soils and it has been studied as a model organism. The flowers are 5 petaled and symmetric, a bit like an orchid. The opposite leaves are oval and young leaves are coated with small hairs. The leaves are edible.



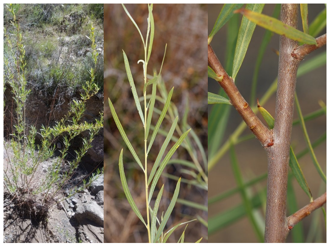
Blue elderberry (Sambucus mexicana) 🌿 ▼grows in temperate regions either on the coast or upper mountains. The leaves are compound symmetric finely serrated leaflets. The stems, bark and leaves contain cyanogenic compounds but the berries and flowers have been used as a food source for millennia. The white flowers grow in bunches and berries are dark with a chalky coating



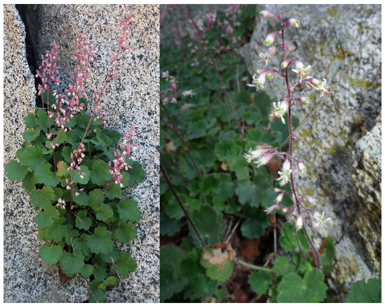
Incense Cedar (Calocedrus decurrens) 🌱▲ Grows in the upper sierras, leaves grow in flat scaly sprays arranged oppositely. Bark is smooth when young and grow increasingly scaly. Despite cedars being in the Pinaceae family, the plant is in Cupressacae



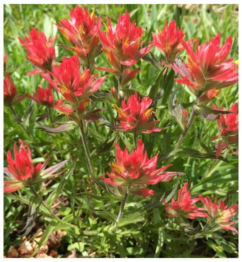
White fir (Abies concolor) 🌿 ▲ Grows above 3000ft. Needles are blue-green and flattened. Leaves do not occur in clusters and spiral along the branch and are upswept. Cones sit vertically on the branch



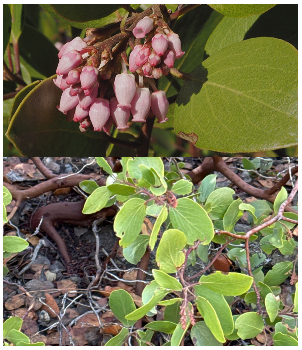
Narrow Leaf willow (Salix exigua) 🌿 ▲ Grows along rivers as upright stalks all stemming from a common base as it spreads by root sprout. The young shoots can be eaten and the stems were used extensively for weaving and construction.



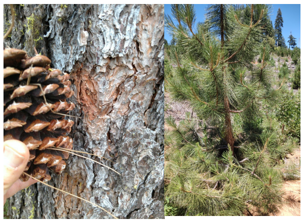
Pink Alumroot (Heuchera rubescens) 🌿 ▲ found primarily in the sierras at higher elevation. Grows basal leave with a center stalk with drooping flowers, leaves can be eaten but taste bitter.



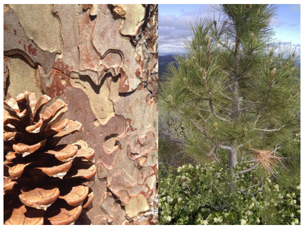
Common Red Paintbrush (Castilleja miniata) 🌿▲ many branching stems from one tap root. Bunches of modified leaves contain small tubular flowers. The plant is partially parasite, able to steal water from the root systems of other plants in times of drought. The roots and stems concentrate Selenium.



(Greenleaf Manzanita) Arctostaphylos patula 🌿 ▲▼ shrub with woody red stems, one of the most widespread manzanita species in america. Leaves are smooth and round with a lighter silvery underside. The berries are edible and has been used as a food source for millennia. Generally found above 1000 ft



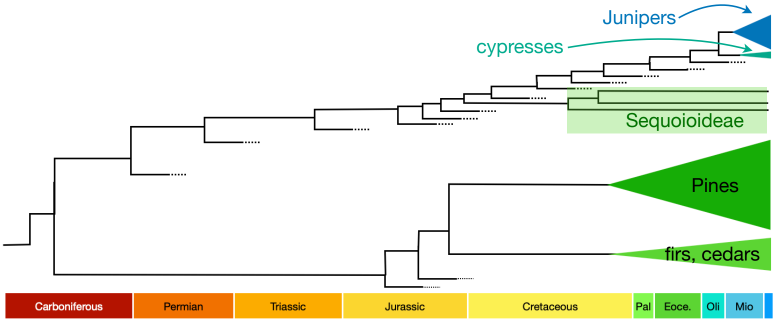
Jeffery Pine (Pinus jeffreyi) 🌱 ▲ Tolerant of serpentine soils and grows above 5000ft. Cones have inward pointing spines and the needles are greyer than the closely related ponderosa pine, the resin contain high amounts of n-heptanes, making it smell like butterscotch.

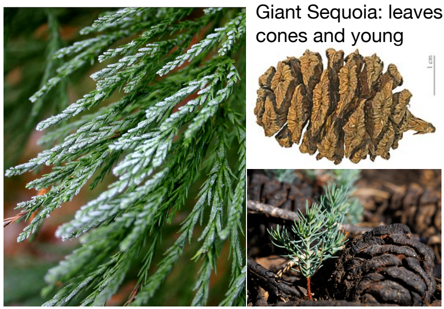


Ponderosa Pine (Pinus ponderosa) 🌿 ▲ Grows in the altitudes, needles are in bight green clusters of 3, the terpenes in the resin have also been reported to smell of butterscotch.

Recognizing Giant Sequoias

Conifers (cone producing plants) predate flowering plants, appearing in the fossil record around 300 mya and are now relict species, living in much restricted zones of their former habitats. The giant sequoias are within the family Cupressaceae (cypresses) but is noted for it's history in the fossil record, appearing as early as the mid cretaceous. It is one 3 remaining species in the sub family Sequoioideae with the coastal redwood sharing a genus, and the metasequoia in Hubei provence, China the remaining other member. Like Other Cypruss sequoia have scaly leaves and small round cones. While common names for plants do not follow actual phylogeny, the scaly leaves are indicative of the genus Juniperus (in family Cupressaceae) while the Pinacea family has needles, either flat as on firs and cedars within the genus cedrus (note the cedar above is Cupressaceae), spiraling the stem like spruces, or clustered in Pines (genus pinus).





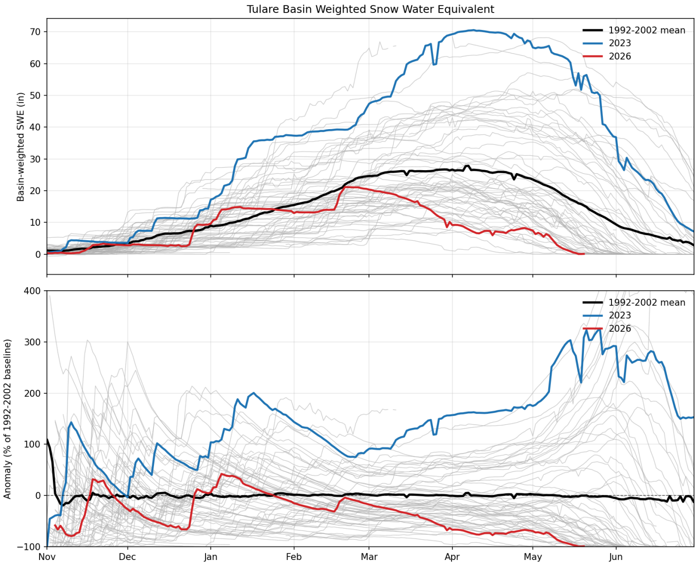
Giant Sequoia: leaves, cones and young

Images and identification from CalFlora.org, Wikipedia, and iNaturalist, Sequoia images from nps.gov. Leslie, (2014). C. New Phytologist, 203(4)

(24) Diminishing Sierra Snowpack & Downstream Effects on Reservoirs — *Zachary Glaser*

Zach Glaser, Ge136, Spring 2026

Dramatic Snowpack Decline in the Sierra Nevada and Downstream Effects



Overview and Snowpack Decline

At seasonal maximum, forty cubic kilometers of water are held in snowpack in the Sierra Nevada. As the Sierran snow melts during spring and summer and flows into downstream basins, it makes up nearly a third of California's water supply. Climate change is disrupting the formation, storage, and discharge of water. April-July runoff has decreased 20% since preindustrial temperatures and is anticipated to drop substantially further. In any given year, however, long term trends are dominated by internal climate variability. [1] The years with the smallest recorded snowpack, 2014 and 2015, were associated with the 2011-2017 California drought. Attributing events to climate change is methodologically fraught and scientifically contentious *[citation needed]* but attempts to quantify the contribution of anthropogenic warming and precipitation shifts to 2014 drought conditions only explain 5-18% of observed variability. [2] While 2026 represents one of the lowest integrated snowpacks on record and will profoundly affect the region this year, just three years ago marked one of the highest and most persistent snow accumulations recorded in the Sierra Nevada. [3]

Cause Attribution

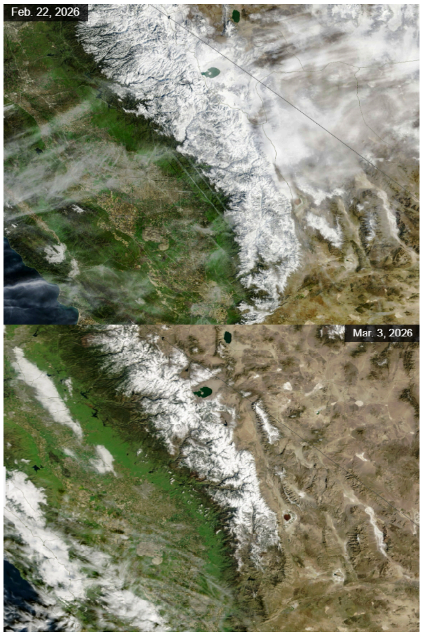
Climate change will strain regional water supplies while simultaneously increasing net precipitation. Warmer air holds more moisture (at the Clausius-Clapyron relation of 7%/°K), with geographically heterogeneous effects, but generally increasing the frequency of high intensity precipitation. Simulation studies show that precipitation will substantially increase over the Sierra Nevada during the winter wet season. Atmospheric rivers are a dominant pattern of precipitation in California winters, producing a majority of Sierran snow. The relatively warm and moist atmospheric river air mass keeps precipitation within a few degrees of freezing, so marginal temperature shifts can tip whole events from snow to rain. Thus the Sierras accumulate more rain, but less snow, shifting Sierran water capacity from snowpack–which stores and releases water well into the agriculture season–into a supply that peaks in winter when demand is low and then quickly depletes. [4]

Warmer temperatures straightforwardly reduce the longevity of the Sierran snowpack, and several local feedback mechanisms enhance its decline. Greenhouse warming can be locally exacerbated by snow albedo effects, with reduced snow coverage exposing less reflective rock, leading to further warming and melt. Additionally, both increased temperatures and decreased water supply in the Sierra Nevada historically correlate with higher wildfire area burned. This in turn leads to the deposition of aerosolized black carbon onto snow, decreasing its albedo and raising the melting rate. [5]

Effects on Water Resources and Ecology

The vast majority of water resources (~80%) in the Southern Sierra Nevada are used in agriculture. While some water is imported from elsewhere in the state, most demand is met from a combination of groundwater and snow melt, with variability in snowpack leveraging the groundwater share between 33% and 70% of the overall water budget. When snowpack is low, it forces excess groundwater removal, leading to overdrafting, well failure, and land subsidence. In 2024, California's State Water Resources Control Board took its first ever probationary action in the Tulare Lake subbasin, requiring farmers to report and pay for water pumping to achieve the Sustainable Groundwater Management Act goal of groundwater sustainability by 2040. [6]

Mountain ecosystems are vulnerable to significant disruption with reduced and quickly depleted snowpack. Snowpack governs late-season vegetation conditions more strongly than precipitation or evaporation driven by local temperature and humidity. Meadows in alpine and subalpine regions that receive substantial glacial runoff, with plant growth cycles adapted to current melt rates. Without consistent snowpack, these ecosystems–where geology often precludes long-term subsurface water storage–have no water supply for much of the year. [7]



Local wildlife that depend on meadow vegetation, like Belding's ground squirrel, are expected to decline in population as their habitat shrinks. More glaringly, ecologies within meltwater streams themselves are substantially altered by warming water or simply disappear when snowmelt abruptly exhausts months early. This threatens the extinction of several salmonid species that migrate between freshwater streams and brackish estuaries, alongside amphibian species like mountain yellow-legged frogs which require habitats wet by meltwater streams to reproduce. [8]

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(Fig. 1) See [3]

(Fig. 2) Adapted from Castleman, T.. Satellite photos show California's sudden snowpack meltdown. *Los Angeles Times* (5 March 2026).

— Isabella Dam —

(25) Geothermal Energy in California — Casa Diablo IV — *Elizabeth Heiny*

(0) How do geothermal plants work?

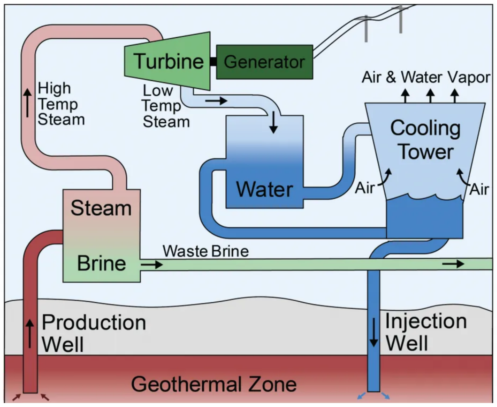
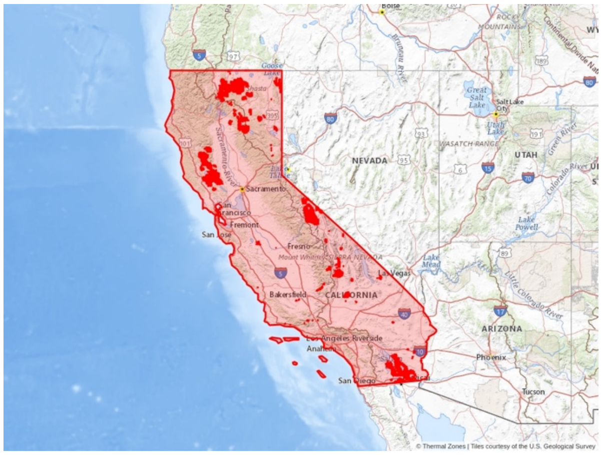

Turbine
Generator
High Temp Steam
Low Temp Steam
Air & Water Vapor
Cooling Tower
Water
Air
Air
Steam
Brine
Waste Brine
Production Well
Injection Well
Geothermal Zone

Figure 1: A "flash steam plant" (from https://css.umich.edu/publications/factsheets/energy/geothermal-energy-factsheet)

Hydrothermal energy from underground water reservoirs is the main thermal source for geothermal electricity generation, so the main geologic ingredients necessary for development of geothermal plants in a given site are: (1) heat, (2) fluid, and (3) permeability. Figure 1 shows schematically the process of electricity generation in a "flash steam plant", which is the most common type of geothermal plant worldwide. In these facilities, high pressure hot water is pumped into low pressure surface tanks, where it "flashes" rapidly to form the steam that is used to spin turbine generators. As a late substitution into the class (on behalf of Simon Andren), I adopted directly his chosen topic (geothermal energy in California). However, in preparing this report, I realized quickly that most of the geothermal facilities in central California are located to the east –– not to the west (i.e., where we are) — of the Sierra Nevada, so I'll instead be focusing on why these geothermal facilities cluster on one edge of the Sierra over the other, going sequentially through this problem in terms of (1) heat, and (2) fluid / permeability.


NEVADA
UTAH
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Bakersfield
Los Angeles
Riverside
Anaheim
San Diego
Las Vegas
Phoenix
Tucson
Salt Lake City
Great Salt Lake
Lake Mead
Lake Powell
© Thermal Zones | Tiles courtesy of the U.S. Geological Survey

Figure 2: A map of geothermal energy zones in CA (https://thermalzones.com/usa/california)

(1) Heat

As is shown in Figure 2, the Basin and Range province is located to the east of the Sierra Nevada. Although extreme local variations are present, the average heat flow is relatively high throughout this region (85 W/m^2; for context, typical values for stable craton interiors are ~40-60 W/m^2) (Blackwell, 1983). This high average heat flow is, to first order, a function of the extension that drives crustal thinning. This extension allows upwelling material from the asthenosphere to rise closer to the surface, steepening the local geothermal gradient. As a rule of thumb, for half the crustal thickness, heat from below reaches the near surface at approximately twice the rate). It also promotes decompression-induced volcanism, with the magma produced by this process intruding into the crust and releasing heat as it crystallizes. Such intrusive volcanism is the primary source of some localized heat flow anomalies at some sites that you might be familiar with within this region (e.g., Sulfur Creek just south of Mammoth). In contrast, the western edge of the Sierra sits on cold, thick, and geologically stable crust, and it is not a region of high heat flux.

(2) Fluid / permeability

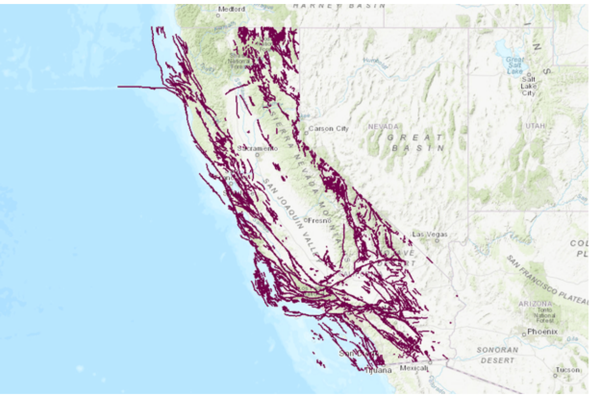

Figure 3: map of active faults in CA (https://databasin.org/datasets/de61016e429d41099a4bda10cbae86b4/)

The Walker Lane belt is a 60-mile wide, 500-mile-long active seismic zone that stretches from the Eastern California Sheer Zone to northeastern California (Faulds and Henry, 2008; wikipedia). This system separates the eastern edge of the Sierra Nevada batholith from the Basin and Range province that we discussed in Section (1). It is dominated specifically by NW-striking right-lateral faults and accommodates ~20% of the North American-Pacific plate motion in the western Great Basin. It is also linked closely to the N- to NNE-striking normal fault systems throughout the region (Faulds and Henry, 2008). Geothermal systems are concentrated in areas with the highest strain rates, which occurs often in transtensional areas (i.e., where you have both lateral and pull apart motion). In particular, these extensional/transtensional faults that I've referred to are key for supporting geothermal systems because these fractured, permeable fault zones allow groundwater to circulate deep into the lithosphere, be heated, and rise back to the near-surface where it's heat can be extracted in plants (like the flash steam plant in Fig. 1) (CA energy). Although there exist some smaller fault systems on the western margin of the Sierra, they are small and infrequent relative to those on the Eastern margin.

With this knowledge of the Sierran asymmetry, it's not hard to imagine that the development of geothermal largely in the eastern vs. western Sierra was not accidental. These geothermal projects were spurred largely by the 1970s energy crisis, which drove federal and private investment into alternative energy sources. Early production at the Mammoth complex came from geothermal leases on private lands and later from public lands originally explored by several developers leased during BLM lease sales. Relatively quickly, Ormat Technologies became the dominant player in the region and acquired and operated the Mammoth / Casa Diablo complex near Long Valley. Casa Diablo IV, which came online in July 2022, was the first geothermal plant built in more than three decades within the CAISO grid.

Heat flow in the northern Basin and Range Province (Blackwell, 1983).
https://css.umich.edu/publications/factsheets/energy/geothermal-energy-factsheet
https://www.energy.ca.gov/data-reports/california-power-generation-and-power-sources/geothermal-energy

Understanding Yokuts and Tübatulabal Creation Stories

Pablo Drake Hernández, Ge 136c, 2026

The Yokuts and the Tübatulabal are two Indigenous peoples of what is now central California. Despite their geographic proximity—the Yokuts traditionally inhabited the Central Valley and the western foothills of the Sierra Nevada, while the Tübatulabal occupied the Kern River basin—they belong to distinct linguistic families. This distinction suggests that their narrative traditions emerged independently, even as both peoples interacted with a shared environment. I aim here to contextualize and examine their creation stories, finding common cosmological themes.

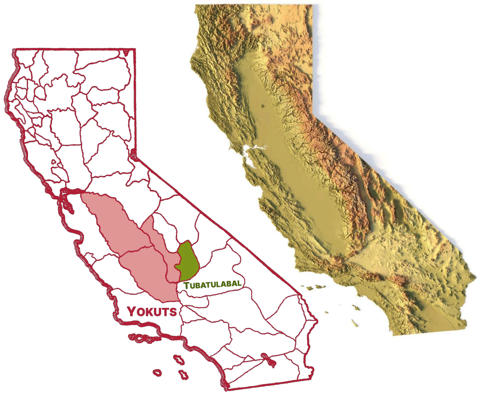

Figure 1: On the left, territories under control of the Yokuts and Tubatulabal [California Indian Library Collection, UC Berkeley]. On the right, topographic map of California. [USGS]

Society & Subsistence

The Yokuts and the Tübatulabal shared several cultural and economic practices. In the absence of agriculture, both relied on gathering acorns, hunting, and fishing for subsistence. They also participated in trade networks linking coastal California with the Great Basin, and developed sophisticated basketry traditions with intricate geometric designs. Despite these similarities, the two peoples differed in social organization. The Yokuts consisted of ~60 autonomous tribes organized into moieties and ruled by hereditary chiefs, whereas the Tübatulabal formed a smaller, semi-nomadic society. Although the groups interacted peacefully through trade, tensions may at times have led to violent conflict.

Rituals, Beliefs and Myths

Despite their linguistic differences, Yokuts and Tübatulabal shared several religious and ritual traditions. Both societies believed in animal spirits, emphasized connections between humans and non-human beings. Individuals with supernatural powers were recognized as doctors/shamans, and they were ascribed the capacity to heal (or harm), but also to control the weather, or fend off rattlesnakes and bears.

One particularly significant Yokuts ceremony was the annual mourning rite, a six-day outdoor event attended by ~1000s of people. It honored those who had passed away during the preceding year, through dances, rituals, and the burning of the deceased’s possessions.

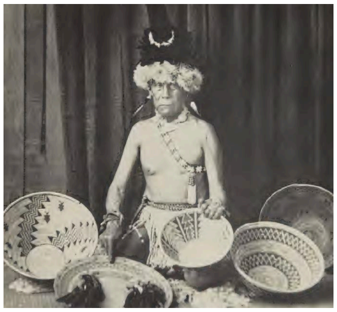

Figure 2: Sinel, noted Tache Yokuts Rain Dancer and Doctor in his ceremonial costume, called juek. [Handbook of Yokuts Indians, Frank F. Latta]

Figure 3: Spanish Mission San Luis Rey, 1895 [Bowers Museum]

Spanish Colonization: The Missions

First contact between the Yokuts and Spanish colonizers occurred in the 1770s, when the Yokuts population is estimated to have ranged between 25,000 and 70,000 people. In the following decades, many Yokuts were forcibly displaced into Franciscan missions, where disease and forced labor led to severe population decline. Although the Tübatulabal also encountered the Spaniards in 1776, their more isolated geographic position limited direct colonial control. Yet, epidemic diseases still affected their communities.

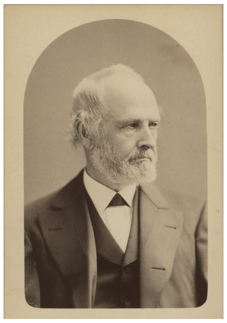

Figure 4: Peter Burnett, first governor of California. Waged war against indigenous peoples and tried to enact an exclusion law for the state. [Oregon Encyclopedia]

An American Genocide

From 1848, under American rule, Indigenous peoples were stripped of all rights and persecuted. The California Gold Rush prompted a massive wave of settlers, who formed militias that displaced and killed Native populations. In 1850, capture and enslavement of Native Americans became formally legalized. Over the following decades, coordinated, state-sponsored massacres devastated tribes, reducing the Yokuts population to ~600 individuals and the Tübatulabal to ~100 by 1900.

Tübatulabal Creation Myth

[Extract]

It is raining all the time
The water filled this earth
Everyone, they ran away towards the mountain
"We get slaughtered," says Coyote
Coyote is ready to die
He has no food

Coyote then said, “Let someone dive there; he will make earth appear; who will make earth appear there?”

Mud-Diver dived and, after a while, came out
holding very little (earth)
Then everyone saw it
Then from there Mud-Diver put the earth in the middle of the water
Mud-Diver made the earth appear
There it is ended.

Interpreting Creation Stories

The excerpts above reveal a shared cosmological worldview between the Yokuts and Tübatulabal, one that gave meaning to their geological environment and reinforced their social structures.
However, these oral traditions were transcribed by academics in the early 20th century. treating them as timeless, static representations of these cultures would be an oversimplification.
It may be more fruitful to view these narratives as a way of engaging with Western religious frameworks, all while enduring a century of colonialism and genocide.

Both creation tales invoke a ‘spirit animal’ figure (Coyote for the Tübatulabal and the Eagle for the Yokuts) creating land in a flooded world. This animal is referred to as a “God” in a transcript from the Dumna Yokut tribe

Yokuts Creation Myth

[Combination of Sources]

Everything was water except a very small piece of ground.
On this were the Eagle and Coyote.
They sent the Turtle to dive for the earth at the bottom of the water.
When it came up again, Coyote looked closely at its nails.
At last he found a grain of earth.
From it they made the earth as large as it is.

The Eagle said: “Do not touch it for six days. Let it dry first.”
But soon Coyote said: “I will try it. It is getting hard now.”
He traveled along where the Sierras are.
That is why these are rough and broken now.

Yokuts narratives explain the existence/ appearance of the Sierras & Coast Range

When the morning star appeared, the Eagle told the Wolf: “Shout!”
and he shouted three times.
The Earth was shaken by an earthquake, but it stood.

Earthquakes are also presented as a consequence of the spirit animals’ actions

From the earth they also made six men and six women.
They sent these out in pairs in different directions and the people separated.

*“Now,” said Eagle, “we have to **be** different kinds of people.*
There will be one couple for each kind of tribe."

Then all the birds came and asked what they were going to be. Then he named a pair for each tribe of people and gave them a place.

Then Coyote said :
‘”We will make a woman of a deer.”
Then they killed a deer. They put it under a blanket of tules.
When the morning star came it got up. It was a person now. It was a woman.
Coyote said: "I will sleep with her."

Different Yokuts tribes had different stories for the creation of humanity, three are highlighted here: Note the references to tribal organization and shamans (animal-human transformation)

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Tuyako Khristoforova
GE 136C

Hospital Rock: Tübatulabal, Yokuts, and Potwisha Native Americans

Background

Hospital Rock, located in the Sequoia National Park near the Middle Fork of the Kaweah River, is an important Native American cultural site, which is a large quartzite rock, connected to the Indigenous peoples of the southern Sierra Nevada, including the Tübatulabal, Yokuts, and Potwisha Native Americans. [1] Hospital Rock was known by local Native Americans as Pah-din, meaning "place to go through." [2] Pah-din was once a village that supported hundreds of California Native Americans. It was not simply a village but also a place of movement, gathering, ceremony, and healing. According to the National Park Service, healers sometimes cared for injured travelers there, which influenced the English name "Hospital Rock." [2]

One of the most visible cultural features at Hospital Rock is its pictographs, which are painted images on rock surfaces as shown in Figure 1. The National Park Service emphasizes that the pictographs are sacred to Native communities and are part of traditional belief systems, comparable in importance to places of worship. Visitors are asked not to touch, mark, or damage the rocks. [3]

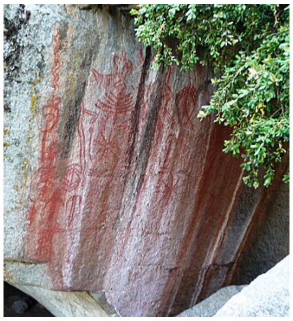

Figure 1. Hospital Rock Pictograph at Sequoia National Park. The pictograph has red-painted designs on the granite surface.

Hospital Rock also shows the complicated history of Native displacement. The creation of national parks often preserved landscapes from some forms of development, but it also separated Native people from lands they had used and cared for. The National Park Service now acknowledges that forced relocation deeply affected Native peoples' relationships with park lands. Sequoia National Park protected giant sequoias and mountain ecosystems, but that protection happened within a colonial system that often ignored or removed the Indigenous communities who already belonged to those places. [2]

Today, it remains meaningful to the descendants of that community, while also serving as a place where visitors from many backgrounds come to experience the beauty of it. The Hospital Rock area has hot, dry summers and cool, wet winters, and its surrounding hillsides and valley floor were shaped over time by snow, ice, and flowing water. Several large granite boulders in the area offered temporary shelter and space for tribal gatherings. The main rock, known as Pah-din or Hospital Rock, is especially large, measuring about 60 feet long and 20 feet wide. [2]

Tübatulabal

The Tübatulabal were one of the Native peoples connected to the southern Sierra Nevada region. Their traditional homeland was mainly in the Kern River Valley, including the Kern and South Fork Kern River drainages, but their territory and cultural connections also reached into areas that are now part of Sequoia National Park. Their name is often translated as "pine-nut eaters," referring to the gathering of piñon nuts, an important food source. In Figure 2, there is evidence of that being seen in the bedrock mortars found in the area. These grinding holes were used by Native peoples to process foods like acorns, seeds, and nuts. [4] Their presence helps connect the physical landscape to the everyday practices that sustained Native communities at Hospital Rock.

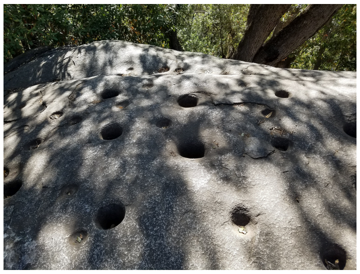

Figure 2. Bedrock mortars at Hospital Rock. These circular grinding holes were formed through repeated use by Native peoples processing foods such as acorns, seeds, and nuts.

Yokuts

The Yokuts were one of the major Native peoples of Tulare County and the southern Sierra region. In the Kaweah and Tule River areas, two Yokuts groups were especially important: the Wukchumni, who lived near the Kaweah River, and the Yaudanchi, who lived near the Tule River. According to *Tulare County Treasures*, these groups settled along the lower waterways and alluvial plains of the Kaweah and Tule rivers, where they developed permanent winter villages and relied on the region's rivers, foothills, and valley resources. [5] Their way of life was deeply connected to conservation. They rotated hunting and gathering areas so resources would not be depleted, used fire carefully to clear brush and encourage new plant growth, and gathered only what they needed. They also practiced pruning and selective cutting rather than large-scale farming, showing that they actively managed the landscape instead of simply living off it. This makes the Yokuts important to understanding Hospital Rock because their presence in the Kaweah River region shows that Native peoples shaped the southern Sierra landscape through careful environmental knowledge and long-term conservation practices. [5]

Potwisha

The Potwisha were especially associated with the Hospital Rock area. They are usually described as a subgroup of the Monache or Western Mono, who lived in the foothills and mountains of the southern Sierra. Local histories describe Potwisha and Wuksachi communities as having semi-permanent settlements near present-day Three Rivers, including a major village at Hospital Rock. [5] This shows that Hospital Rock was not an empty "wilderness" before the creation of the national park.

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(28) Thenardite Mineralogy and Soda Lake — *Annie Edwards*

Soda Lake, soda lakes, and also what is thénardite?

Annie Edwards – Ge 136c – Spring 2026

Soda Lake

Soda Lake is a shallow ephemeral lake on the eastern border of San Luis Obispo County. The Temblor Range, Caliente Range, and the San Juan Hills surround and drain into the lake. Not to be confused with the category of lake known as soda or alkali lakes, which is broadly defined as an extremely alkaline or basic lake that typically have pHs ranging between 9 and 12. Fortunately for us, Soda Lake, located in the Carrizo Plain of San Luis Obispo County is indeed a soda/alkaline lake. However, for clarity, the categorization of lake will henceforth be called an alkaline lake, and all uses of Soda Lake refer to the specific lake discussed. Soda lakes alkali nature is in large part because it is the closed drainage basin to the rest of the watershed. The drainage of the basin tectonically shifted to create Soda Lake in the late Pleistocene through uplift in the Temblor Range[1]. As a result, salts and sediment from the watershed were concentrated into the lake as water evaporated. Soda Lake and other closed basin lakes are often used as paleoclimate records, as they have long-stretching sedimentary records that often integrate local climate and hydrological changes in the watershed.

Figure 1. Top. Image of sandhill cranes in central California, photographed by Jay Huang. *Bottom.* Jared's Peppergrass in Carrizo Plain photographed by George Butterworth

Flora and Fauna

As one of the largest undisturbed alkali wetlands remaining in California, Soda Lake provides an important environment for local and migratory flora and fauna. For example, lake is a wintering area for sandhill cranes. The alkaline conditions of Soda Lake make it home to the native and endemic Jared's peppergrass (*Lepidium jaredii*), localized nearly exclusively to the Soda Lake watershed[2].

Thénardite Mineralogy and Paleoclimate Interpretations

Thénardite is a relatively rare anhydrous sulfate bearing salt (chemical formula: Na_2SO_4) often occurring as evaporites in arid regions. Models done on the nearby saline, but open basin, Owens Lake have shown compared to other sulfate salts (hydrous mirabilite and CO^{2-}_3 bearing burkeite) that thénardite is preferred in higher temperature and higher brine pCO_2 conditions (between 23 °C and 26 °C, and $pCO_2 > 700$ ppm)[3]. Thénardite formation typically occurs when lake $pCO_2 > 700$ ppm, several times higher than atmospheric pCO_2 in recent geologic history. Potential reasons may include carbonate precipitation, biological respiration, or short irregular outgassing events from faults. The lattermost may be indicated by sharp transitions in the evaporite record, as have been found in Searles Lake, Ca[4].

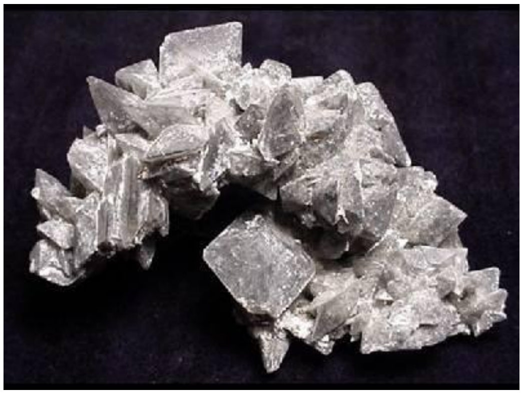

Figure 2. Thénardite from Soda Lake, Carrizo Plain. Photo copyrighted by Charles Creekmur.

Other possible interpretations of evaporite deposits include those relating to water flow and lake desiccation. For instance, the period from 35 to 60 ka which formed large rapidly deposited (1.7—3.8 m/ky) halite deposits in Death Valley was interpreted as a period where the lake was commonly dry, yet also received enough water flow to bring in new solutes that evaporated out[5]. Evidence suggests that inflow to Soda Lake has primarily been runoff waters throughout its history. However, due to the intensely arid environment evaporative processes dominate over precipitation, and so there is minimal subaqueous evaporite formation[1]. Instead, evaporites are found as crystals embedded within clays and other sedimentary deposits.

The Soda Lake Origin of Life Theory

Phosphorus is an element at the backbone of many biochemical structures fundamental to life, such as DNA, RNA, and ATP. However, phosphorus is naturally sparse in the environment, and much of life today is phosphorous limited. Laboratory experiments have demonstrated that prebiotic chemistries would've likely required an environment capable of sustaining high concentrations (up to 100 µM) of phosphate rarely seen in nature today. Recent work has suggested that closed lake environments, such as soda lakes, may be a candidate for such an environment. In the typical lacustrine environment, calcium and phosphate bind to form biologically unavailable apatite minerals. However, due to the highly evaporative and carbonate rich nature of soda lakes, calcium instead binds to form calcium carbonates, thus leaving dissolved phosphate in much higher concentrations than other environments. Recent work from ETH Zurich (2025) has suggested that large soda lakes may support a high enough phosphate concentration and flux to have sustained the needs of early life[6].

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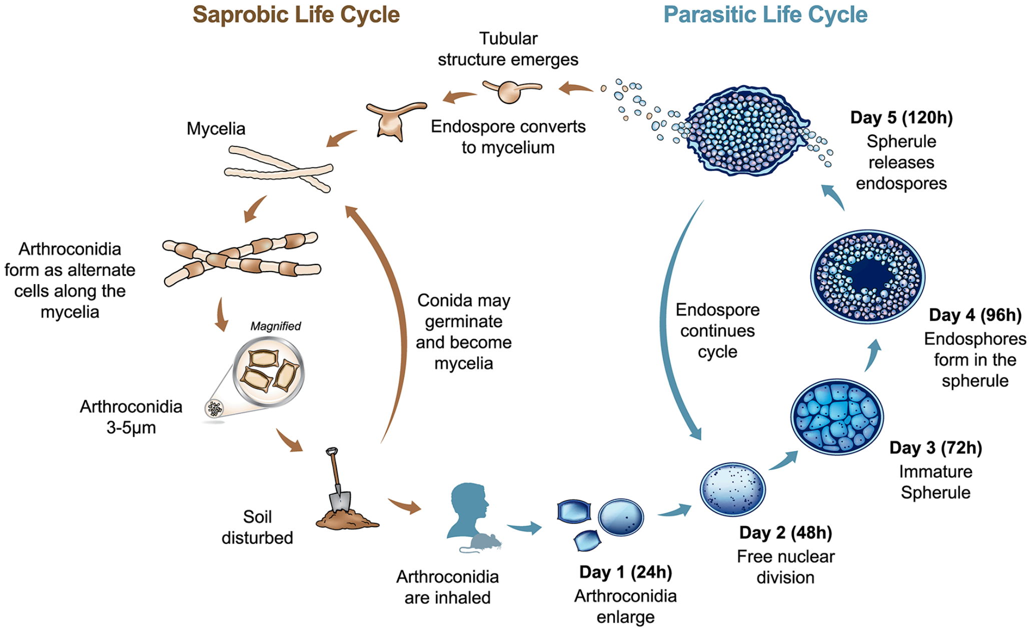
Valley Fever (Coccidioidomycosis)

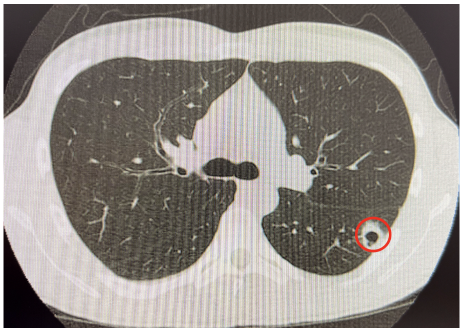
Korbi Thalhammer

San Joaquin Valley Fever (also known as Valley Fever, Coccidioidomycosis, or Cocci), is a chronic illness caused by two species of soil-dwelling fungi in the *Coccidioides* genus: *C. immitus* and *C. posadasii*. These fungi are dimorphic, meaning they adopt different morphologies in the soil organism (where they form filaments) and in the host (where they form spherules). In the soil, the fungi form hyphae, which can segment into spores (arthroconidia) that break off and become airborne when soil is disturbed, e.g. by digging, driving, or wind. When these arthroconidia are inhaled, the fungus begins a new lifecycle in the host (see Fig 1).

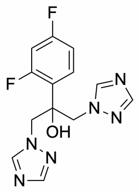

Saprobic Life Cycle
Parasitic Life Cycle
Tubular structure emerges
Endospore converts to mycelium
Mycelia
Arthroconidia form as alternate cells along the mycelia
Magnified
Arthroconidia 3-5µm
Conida may germinate and become mycelia
Soil disturbed
Arthroconidia are inhaled
Day 1 (24h)
Arthroconidia enlarge
Day 2 (48h)
Free nuclear division
Day 3 (72h)
Immature Spherule
Day 4 (96h)
Endosphores form in the spherule
Day 5 (120h)
Spherule releases endospores
Endospore continues cycle

Life Cycle of *Coccidioides*

Figure 1 from Reference 3.



While in most cases the disease is "self limiting", meaning it is controlled by the immune system without external intervention, in some cases (exceptionally high fungal loads, particularly virulent strains of fungus, or immunocompromised individuals), the disease can cause a chronic condition or even disseminate from the lungs to the rest of the body.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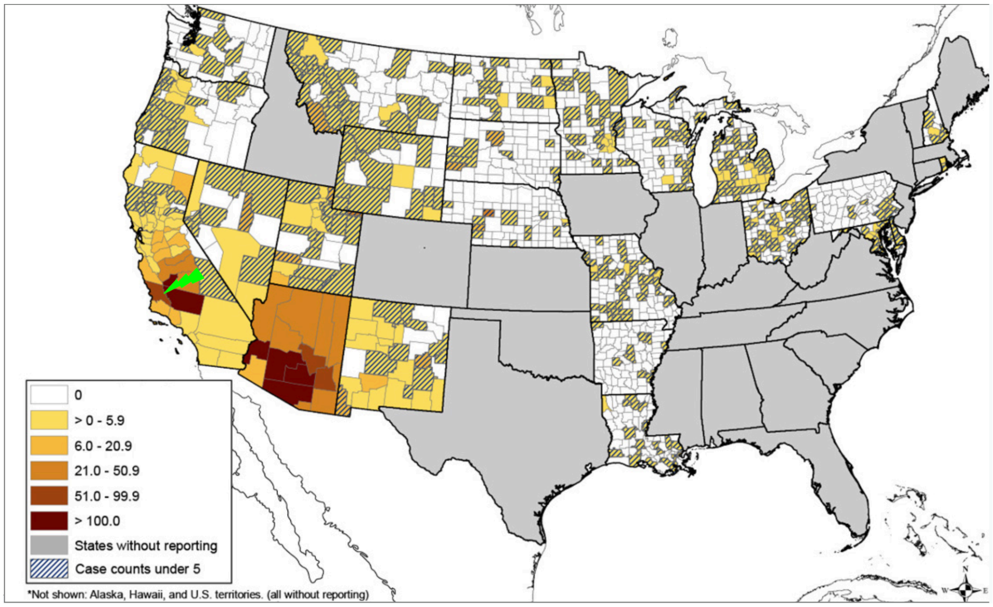
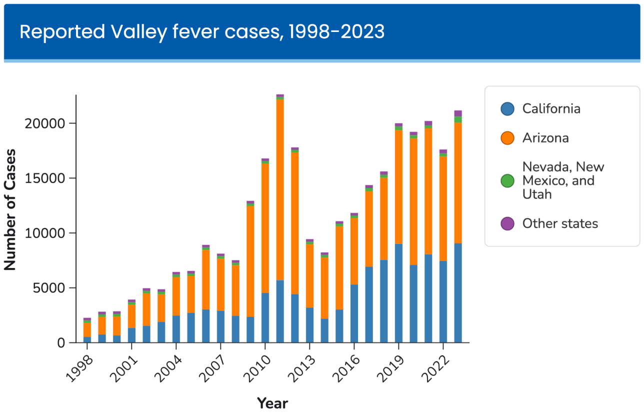
The case of Valley Fever I acquired while working on Ge121A in the Carrizo Plain in Fall 2021 resulted in flu-like symptoms, debilitating neck and back pain, and a 3cm spherule in my lung that will never go away and likely harbors spores that could disseminate later in life (Fig 2).

When I arrived at the hospital, I was screened for dissemination to the brain and spinal cord using a CT scan and a spinal tap. In cases necessitating treatment, drugs in the azole class, like fluconazole (pictured at right) are employed, often for life. Because fungi are eukaryotic and have highly similar biology to humans, these antifungal drugs are much harder on people than antibiotics targeting bacteria. Fluconazole, for example, saved my life but is hard on the liver: I need consistent blood tests to check my enzyme levels.

The disease is endemic in parts of several western states including California, Arizona, New Mexico, Texas, and Utah. It is also prevalent in northern Mexico and parts of Latin America. In some cases, wind storms have caused outbreaks of the disease hundreds of miles from a fungal source. Climate change is expanding the range of the fungus, and it has recently caused infections in northern states that were historically considered cocci-free.



Map of average annual reported case counts in the United States 2011-2017. Tip of green lightning bolt marks approximate location of Ge121A trip from Fall 2021, where 12 people were exposed to *Coccidioides sp.* spores via unprotected digging. Six contracted Valley Fever.



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2. https://www.cdc.gov/valley-fever/php/statistics/index.html
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6 I Turned My Talk In Late and Now Its a Handout!

The following talks were turned in late and are distributed as printed handouts in class rather than reproduced in this guide. They appear in the Table of Contents in their scheduled order (flagged as handouts) but their pages are not included here to save space. **Each author is responsible for bringing enough printed copies for the whole group.**

- **Abby Keebler** — Tejon Oil Country: Geologic and Human History
  (Day 1 — Colonel Allensworth State Historic Park)
- **Ruth Moorman** — Atmospheric Rivers and Flooding in California
  (Day 1 — Vernal Pools & Mortar Bowls)

S	E	Q	U	O	I	A
See at least 4 constellations	Saw a tree older than 1000 yrs!	What's that rock doing here?	Granite!	Cow!	Do some dishes!	Chew some gum courtesy of Joe
Big Tree!	Enter the Sierras	Make a new friend!	Listen into some truckers on the radio	Recite a John Muir quote from memory	Put on sunscreen!	Unload / load the truck
Farm!	Cave!	Tent problems...	Make a leaf crown in Kings Canyon	Turn your headlights on!	Snow!	Pump gas
Give geology nicknames to your whole car	Chat with a quirky local	Learn the difference between protolith and batholith	Free!	Evidence of glacial activity	Take a pic for the gram (must get posted)	Uh oh, car problems
Spot 5 different types of wildflower	Lizard!	Bird!	Learn who General Sherman is	Find a pegmatite	Float down a river	Pick up trash
Soaked in some hot springs	Deer!	Lake!	Help un-stick a vehicle	Practice leave no trace	Recite a prayer with Joe	Pass 5 cybertrucks
Take a polar plunge!	Funny vanity plate	Slugbug!	Passed 3 chipotles	Learn what happens at a fish hatchery	Help make dinner	Sing along to "Life is a Highway" on the highway

Ge 136 Spring 2026

X K O S O A T A V S C J G H J W M A G M A U I H E
O D T F I U K N U R N I S L O O P L A N R E V B D
W H Q I L N C C Q K O R I U M N H O J S W O H E R
I J I V R N U B G N I P H W P X Z O S X J Y M A N
D Y E E Y A T A V E T C D Y R G Y E Y Z Z B M R Y
A E K W G N S W D D A N C H O U Q S H K E M J D D
C I P U O W K A W Y C A U U T U G L S R T V M N W
N N M S L A C T T O I M I D O A R Y Z S I Z Y K E
O O E X O R U E D B F R U I L E G V E U T A O I S
K I R R E R R R F T I E A V I E C U K R A M N R I
P M O C G E T S U A T H K L T M P C C T M E O S F
O S S D D I E H O V R S V G H V O D A T G T M C H
P Y I V O S H E D J E L F L H R T M V L E A R H Y
D H O A X H T D B P S A H A N M V R E U P M S V D
U F N S E K T O E B E R V C J G K V R A Y O E I R
U N B C X E E S T Q D E X I O B C Q N F Q R D N O
E E V A W W G F I W E N C E G E I N N N M P I K T
C O I M R P T B N C W E Z R Y O N R Z G U H M N H
N J I P R E N E A D A G R F L J O U W L H I E D E
B I O I F I O K R H N O Y N A C S G N I K C N O R
B V U N I I D B G K D M G Y O P J M R P R R T Y M
E Z O G S U A Y Y X N O U I F E A D J N E E Z L A
C R R T H Q H O T S P R I N G S T P D B E D V S L
O P O C W R S N D Y C I R X C Q T X X Y L C D I I
W E N J L I V B A T H O L I T H T Y F Y E T G J R
U L G Z T T N A I V I S O T O P E M R O C A W B V

1. Sequoia **2.** Sierra **3.** Kern **4.** River **5.** Mono **6.** Joe **7.** HotSprings
8. KingsCanyon **9.** Cavern **10.** Fish **11.** Kirschvink **12.** Boyden **13.** Rock **14.** Nick
15. Granite **16.** DontGetTheTruckStuck **17.** Metamorphic **18.** Protolith **19.** JohnMuir
20. Glacier **21.** Desertification **22.** GeneralSherman **23.** VernalPools **24.** Batholith
25. Watershed **26.** Isotope **27.** Fault **28.** Magma **29.** Hydrothermal **30.** Bear
31. Camping **32.** Geology **33.** Pegmatite **34.** Erosion **35.** Sediment